# Industrial Symbiosis and the Successional City: Adapting Exchange Networks to Energy Constraints

By

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SUBMITTED TO THE DEPARTMENT OF URBAN STUDIES AND PLANNING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF:

MASTER IN CITY PLANNING
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2007



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# Abstract

Industrial ecology offers models for hybridizing technology and natural processes, human desires and the capacities of ecosystems in an effort to reconcile the expanding conflicts among them. Industrial symbiosis applies this thinking to the scale of the city and its supporting industrial operations.

Case studies of industrial symbiosis, which is the changing of linear, open-loop production to closed-loop systems through the reuse and exchange of waste materials, energy, and knowledge, showcase advantages in waste and energy use reduction within the United States. What are the major limits holding back the widespread development of industrial symbiosis in this country and how can they be overcome? Secondly, what tools can foster its large-scale implementation once the constraints are overcome?

Methodologically, the successful study of the future capacity of industrial symbiosis within the American context must address the future consequences of resources that are no longer cheap nor abundant , as well as the current state of their production, distribution, and consumption. The major constraints facing industrial symbiosis in America are: current extremely high subsidies in transport and resource costs, low symbiosis visibility, non-existent data collection standards, undeveloped communication networks, and no unified regulatory mechanisms. Future limits and cost changes in transport and resources will become the ultimate push to make exchange habits a widespread practice in the United States, enabling the above issues to be effectively addressed. The timing of these limits is uncertain. Yet, planners must be in the right place at the right time with the proper tools to facilitate a transition to the widespread implementation of industrial symbiosis.

This thesis provides a framework for how planners can foster the successful large-scale implementation of industrial symbiosis in the U.S. through a variety of interventions. It suggests four distinct tools: increased visibility of industrial symbiosis through marketing outlets; a new web-based "social-networking" tool for industries to share information and expand communication; a multiple-tiered regulation structure to facilitate standards development; and lastly physical planning that intelligently responds to future trends in energy, resources, mobility, and spatial patterns of industrial development.

# Acknowledgments

First and foremost, I'd like to thank my parents and family. Who would've thought I'd be at MIT writing about resources and industries instead of racing motorcycles or touring around as a rockstar living out of a van? I think they did all along.

Secondly, I'd like to thank my thesis advisor Anne Whiston Spirn. Far more than an advisor, Anne has been a wonderful mentor and great friend throughout my two years here. I cannot express how grateful I am for how much I've learned from her. Truly amazing!

Thirdly, many thanks to both John DeMonchaux and John Fernandez, both of whom provided tremendous insight not only on this thesis, but as instructors throughout my time at MIT.

I'd also like to thank Marsha Gorden and Peter Lowitt for sharing their knowledge and experience with me.

Lastly, I'd like to thank my fellow DUSP'er classmates, who have provided more inspiration and fun than I could've ever imagined. No more planning to plan, let's make it happen!

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# Preface

Sharing is one of the most fundamental concepts we are taught when young. While continually promised it was an essential trait to learn, one cannot deny how many times I exclaimed "mine, mine, MINE!" when asked to share anything with anyone. I vividly remember how difficult it was to overcome the power of entitlement and ownership of my beloved toy motorcycles. The other kids were just too rough with them! I'd get them back without tires, scuffed paint, just a total mess. Only after rewarding victory laps to the ice cream shop, numerous cavities and chocolate stained shirts did I finally come around to understanding there was something to be gained not by giving something, just exchanging it for a little while -- and even then I still wasn't happy about all those missing tires.

One can imagine how difficult it must be for something as large in scale as contemporary industry to consider sharing information, resources, and energy when the current paradigm is to keep to themselves. Why shouldn't they? Everything is currently running smoothly as is, there's no real need for share anything, right?

This thesis strives to explore just how critical it is for contemporary industry in the United States to get used to sharing. While cheap, abundant, subsidized energy and resources have enabled industries to operate without sharing for the past few decades and tremendously grow in scale, the environmental consequences of doing so coupled with natural limits will force this paradigm to shift toward more sustainable practices -- practices that resource sharing could positively contribute to in a large way.

Industrial ecology is a model for achieving balance between economic gain and environmental burden based on closing the loop of waste streams to become material and energy inputs for other industries, 'sharing' valuable resources to be used again. It has been proven to be effective at reducing environmental burden and maintaining economic stability. Yet, it is far from widespread in the most consumptive country in the world, the United States.

Physical proximity is essential to the sharing of resources between industries. It is so important that I had originally singled it out as the deciding factor worth pursing at the level of the *design* of industrial agglomerations. There had to be a better way that *design* could facilitate the sharing of resources, I thought. It seemed an easily answerable question.

Through research I discovered a whole host of issues essential to success of resource exchange. I also discovered that design was only one part of this much larger equation. Even more puzzling was the fact that it seemed so sound for industries to share resources, so why wasn't it a widespread practice here in the United States?

This thesis aims to answer this question. What are the major obstacles holding back the widespread development of industrial symbiosis in this country? Secondly, what tools can foster its large-scale implementation once the constraints are overcome? The following chapters provide a roadmap to understanding these questions.

Chapter one is about situating this work within context: the United States is facing a whole host of issues regarding the future of energy, resources, and society's ability to adapt to such changes. These issues are in dire need of intelligent and immediate response at an enormous scale.

Chapter two introduces a tool and methodology. The practice of industrial ecology aims to provide an operational framework for addressing such issues in energy and resource consumption at multiple scales ranging from virgin material use and product design all the way up to the resource consumption of regions and nations. Industrial symbiosis is the component applicable to the city scale concerned with resource exchange between industries and community.

Chapter three provides case studies of industrial symbiosis. What can we learn from existing, implemented examples of industrial symbiosis? What are the differences in its implementation at various locations, via different organizational structures, and at various scales? What characteristics should be learned from and built upon for the widespread of industrial symbiosis in the United States?

Chapter four identifies the major roadblocks hindering the widespread development of industrial symbiosis in America. If industrial symbiosis is so promising why hasn't it taken root at a massive scale in the United States? What are the major roadblocks? What trends in energy futures offer the opportunity to break the current firewalls and encourage widespread implementation of industrial symbiosis in the United States? What are the characteristics of these scenarios and their implications for industrial symbiosis?

Chapter five makes recommendations for how planners can catalyze the widespread implementation of industrial symbiosis in the United States; the tools they can use to achieve this; the changes in regulatory structure that must be made; and the timescales in which these interventions are possible. It concludes in raising the question: how can future leaders in pushing these agendas be trained?

# Chapter One

*"The fatal metaphor of progress, which means leaving things behind us, has utterly obscured the real idea of growth, which means leaving things inside us." – G.K. Chesterton*

*"Facts are stubborn things." – Tobias George Smollet*

Certainly, I am not the first to point out that modernized society is at a critical point in history. Talk of skyrocketing energy consumption matched with depleting resources is currently widespread, and with ample reason. The negative externalities of fossil fuel dependency, waste production, and over-consumption are showcased daily in the forms of geopolitical instability, climate change, environmental degradation, resource allocation inequality, and debt accumulation. The built environment we construct and inhabit is changing in tandem as well. Existing landscapes are being transformed at an alarming rate and scale into massive horizontal swaths of ecologically high-impact development and infrastructure, continuing the cycle of practices that consume vast quantities of resources. Simply put, many things that Americans know, love, strive for, and take for granted are pegged to massive energy and resource use. Thus, this life predicated on global supply chains, depleting fossil fuel inputs, strained food and water supplies, debt, and perpetual growth will need to change if we are to shift towards a sustainable future.

This thesis is about the adaptive capacity of the built environment to respond to these pressing realities. A means of achieving this adaptive capacity is industrial ecology. Industrial ecology is "the shifting of industrial process from linear (open loop) systems, in which resource and capital investments move through the system to become waste, to a closed loop system where wastes become inputs for new processes."[1] Industrial ecology operates at a variety of scales from the product to the region. A sub-genre of industrial ecology applicable at the city scale is known as industrial symbiosis, which "engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products."[2] Industrial symbiosis is a *tool* that must be placed within the context of change over time. The concept of ecological succession -- the gradual process of change within an ecosystem ultimately arriving at a self-sustaining community -- will be applied to the city, in an effort to deal with energy and resource challenges; industrial symbiosis will be examined as a snapshot of how this could occur. This approach will also "integrate risk assessments of long-

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[1] Most sources on or directly related to industrial ecology fail to provide a concise, easily understood definition of it from their onset – a major part of the problem. This definition is taken from Wikipedia, which cites several of those aforementioned sources: http://en.wikipedia.org/wiki/Industrial_ecology Accessed 20 October 2006. The roots of industrial ecology will be discussed at much greater length in Chapter 1.

[2] Chertow, Marian R. "Industrial Symbiosis: Taxonomy and Literature." Annual Review of Energy and Environment. 2000. 25: 313-37.

term patterns (climate change, fossil fuel declines, water shortages) with processes that determine where, when, and how buildings are built, used, and recycled"[3] -- balanced with current patterns of industrial development and use. This thesis is aimed at a general audience in its methodology and presentation as opposed to a specific, scientific audience, since this kind of information is rarely distributed to people in a tangible, understandable form. The thesis will synthesize and highlight multiple converging paths in practice and theory across a wide variety of disciplines regarding how cities should deal with industrial symbiosis. Recommendations will be made for the planning and design professions to harness and apply the ideas contained within, ultimately facilitating one approach to the successional adaptation of the city in order to deal with environmental impacts and a future of uncertain energy and resources.

We cannot underestimate what we're up against. The potential scale of catastrophe due to inaction is immense if one considers how consumptive and wasteful settlements in the United States are. People will soon have no choice; they must deal with these facts or face dire consequences – emphasized by the recent energy and resource data displayed later in this chapter. Still, it should be noted that cities are no stranger to disaster. As pointed out by Vale and Campanella, "cities have been destroyed throughout history – sacked, shaken, burned, bombed, flooded, starved, irradiated, and poisoned – they have, in almost every case, risen again like the mythic phoenix."[4] This carefully documented and acute observation is true; cities almost always rise again after disaster with inspiring resilience and re-growth. For recent examples, one need look no further than New York City's World Trade Center redevelopment or, at a larger scale, the re-inhabitation of the City of New Orleans after Hurricane Katrina (clearly, neither are perfect forms of resilience, but that is another debate.)

What separates the resilience found in settlements up to this point and the type of pre-programmed resilience needed by the fossil settlement fresh out of smokes is the timescale and typology of the disaster. Until now, most catastrophes have been an event, unexpected or unforeseen, quick and powerful, and, thus, extremely difficult to plan for. A great fire, an earthquake, flood, terrorist attack, or industrial poisoning are all classic examples. The imminent peaking of oil and natural gas operates in a much different fashion. According to the Hirsch Report, an analysis commissioned by an agency of the United States Government in 2005, the peaking of world oil production "presents the U.S. and the world with an unprecedented risk management problem. The economic, social, and political costs will be unprecedented. In summary, the problem of the peaking of world conventional oil production is *unlike any yet faced by modern*

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[3] Kibert, Charles J., Jan Sendzimir, and Bradley Guy, Ed. Construction Ecology: Nature as the Basis for Green Buildings. New York: Spon Press, 2002.

[4] Vale, Lawrence J. and Thomas J. Campanella, Ed. The Resilient City: How Modern Cities Recover From Disaster. New York: Oxford University Press, 2005.

*industrial society."*[5] This can be attributed to the 'out of sight – out of mind' reality of depletion coupled with how dependent society is on these fuels to enable much of what occurs in our everyday lives. The only remotely comparable disaster cities have faced up until this point in history has been the slow, persistent decay of the post-industrial, rust-belt city, as best showcased in places like Detroit, Buffalo, and Cleveland, (which, ironically, was and is largely based on cheap, abundant fuel enabling their industry jobs to migrate to more economically-fertile production zones located halfway around the world.) Vale and Campanella acknowledge this attrition in *the Resilient City*, stating "protracted socioeconomic decay makes urban resilience exceptionally difficult to sustain. This book, focused as it is on more sudden or episodic forms of disruption, therefore stops short of considering this sort of attenuated drama."[6] All the more reason to plan accordingly. If we remain complacent and uninventive amidst the reality of the coming of peak oil, natural gas, and resource consumption, "attenuated drama" is an understatement.

So what does this mean for a thesis on industrial symbiosis, which is about industries sharing things to reduce consumption (and increase profit)? One thing is for sure – the global, distant yet agglomerated scale of present day industry must be considered especially when "the keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity."[7] Everything must be seen as connected. The big picture of the implications of peak oil and gas loom so large it is hard to think of industrial symbiotic relationships making any real dent, especially since industries consume vast amounts of fossil fuels themselves, are predicated on this energy input to perform, and currently have no means of productively re-using waste streams from such combustibles. Robert Ayres writes that "although quantitatively much of the pollution of our environment consists of combustion products from the use of fossil fuels, fossil fuels, as such are not considered in this book [*Industrial Ecology*] inasmuch as there is *no realistic potential for utilizing those combustion products in the economic system."*[8] This statement clearly demands a change in industries themselves, something which would undoubtedly take time and innovation and is built into this thesis. Thus, the *successional* nature of this study: industrial symbiosis must be considered as a tool within a larger toolkit aimed at addressing the big picture of oil, gas, and resource depletion as

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[5] Hirsch, Robert L. Peaking of World Oil Production: Impacts, Mitigation & Risk Management. Science Applications International Corporation. Prepared for the National Energy Technology Laboratory of the United States Government. February 2005. Retrieved 17 November 2005 from http://www.hilltoplancers.org/stories/hirsch0502.pdf For an even more up to date report of the same nature, refer to the GAO report listed in the bibliography.

[6] Vale, Lawrence J. and Thomas J. Campanella, Ed. The Resilient City: How Modern Cities Recover From Disaster. New York: Oxford University Press, 2005. It should be noted that Larry Vale is my academic advisor here at MIT, and all of this picking on his book is, well, somewhat fun from the student's perspective. All in all, a city planning student couldn't ask for a better department head.

7 Chertow, Marian R. "Industrial Symbiosis: Taxonomy and Literature." Annual Review of Energy and Environment. 2000. 25: 313-37

[8] Ayres, Robert U. and Leslie Ayres. Industrial Ecology: Towards Closing the Materials Cycle. Northampton, MA: Edward Elgar Publishing, 1996.

an earlier (read: now) intervention within a timescale of multiple operations aimed at urban self-sufficiency. It raises the notion of the adaptive capacity of the built environment over time, a concept thoroughly treated by urban planner Kevin Lynch.

> "Degrees of adaptability might be measured as the reciprocal of the future cost, discounted to the present, of adapting the spatial system of form and activity to possible future function. Alas, this is an impossible measure – impossible, that is, unless we can specify what costs we speak of, to whom, and what functions we mean, and when, and what level of future performance we require." There is a circularity between adaptability and prediction. If prediction is very good, then adaptability is rather trivial, since it is reduced to the relatively simple technical feat of planning for some present use, to be superseded at a known time by another known use. Yet, if prediction is poor, then how can adaptability be measured, since one is ignorant of what one is likely to have to adapt to?"[9]

At the time this was written over 25 years ago, these thoughts were (and still are) remarkably visionary, promoting the idea that humans as constructors of the built environment, must consider our interventions over time and the undeniable change they will endure. Lynch's space and time thinking is strongly linked to the concept of ecological succession, and ecology in general.

What has changed in 25 years is the understanding of and capacity to predict the parameters Lynch set up for measuring the adaptability of the built environment. Filling in the gaps, if we are to assume "what level of future performance we require" equates to the notion of "sustainable development" defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[10] then there is a lot of work to do, at unprecedented cost. What cost? Converting an un-adaptable society entirely based on massive fossil fuels and consequent environmental degradation to one that is self-sustaining, all without cataclysmic socio-political upheaval. The exorbitant costs will be borne by humanity as a whole, albeit unequally distributed amongst those in developed and developing nations. (In the case of this argument, the "developing" nations have the advantage considering they have a much lesser addiction to the resources in question; however, they will need to find alternative fuels of advancing their needs instead of following the western model based on massive energy inputs.) In terms of 'what functions we mean', this thesis is concerned with a specific part of the necessary changes in spatial patterns of industrial production required of the North American model of fossil intensive development. Planners and urban

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[9] Ibid.

[10] Always a contentious idea to define, this definition of sustainable development is the original from the World Commission on Environment and Development's (the Brundtland Commission) report Our Common Future (Oxford: Oxford University Press, 1987).

designers can have a tremendous positive impact in this important project. When? And the time is now...

## *What American Society is Up Against: Dealing with Forecasts and Predictions*

Industrial ecology aims to reduce consumption of energy, materials and resources. Any strategy with this goal must incorporate future patterns of change within the very resources crucial to its functionality. The most important observation any reader can make about this thesis is when exactly it was written, the spring of 2007. As little as five years ago, most of the energy and resource information this thesis responds to was barely recognized, let alone open to public debate. For example, how often did the term 'global warming' show up in the media five to seven years ago? The large, recent increase in public awareness and debate over global warming can certainly be attributed to accessible and consumer-friendly media such as Al Gore's recent film, "An Inconvenient Truth." Also, and more importantly, scientific reports highlighting this phenomenon are increasingly gaining attention. In February of 2007, the Intergovernmental Panel on Climate Change (IPCC) released its fourth update on global warming, titled "*Climate Change 2007: The Physical Science Basis.*" In a summary to policymakers, it confirms "global atmospheric concentrations of carbon dioxide...have increased markedly as a result of human activities since 1750... [and] are due primarily to *fossil fuel use and land-use change.*"[11] In terms of the affect of global warming on worldwide coastal settlements, the report continues: "anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized."[12] We are also beginning to see expanding research on what this for particular cities. In the April edition of the peer-reviewed journal Environment and Urbanization, a brand new study "shows that 634 million people — one tenth of the global population — live in coastal areas that lie within just ten meters above sea level."[13] As it stands, the scope of this issue and its impact on cities is only beginning to be comprehended but it is undeniably gaining the attention it deserves – and will need to be factored into how cities change over time.

Still, there is a far more pressing issue, more crippling for industrialized societies, whose effects will be felt within a much shorter timescale -- the much less known reality of "peak oil". Far more pertinent to the study of industrial symbiosis, "peak oil as a proper noun...refers to a singular event in history: the

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11 IPCC (Intergovernmental Panel on Climate Change). "Climate Change 2007: The Physical Science Basis: Summary for Policymakers." February 2007. Full report can be retrieved from http://www.aaas.org/news/press_room/climate_change/media/4th_spm2feb07.pdf

12 Ibid.

13 While the April edition of Environment and Urbanization is not yet released, a summary of this report can be found on there website here: http://www.iied.org/mediaroom/releases/070328coastal.html

peak of the entire planet's oil production."[14] It was first studied and understood by then Shell Corporation Geologist M. King Hubbert, who posited "that for any given geographical area, from an individual oil field to the planet as a whole, the rate of petroleum production tends to follow a bell-shaped curve."[15] Hubbert presented this concept in 1956 to the American Petroleum Institute and made two predictions about conventional oil (crude + condensate) production in the United States. The low estimate stated US oil prediction would peak at 150 Giga-Barrels in 1965. The high estimate stated the US peak at 200 Giga-Barrels in 1970.[16] While slightly off in the actual production amount, hindsight displayed that US conventional oil production did indeed peak in 1970 (Figure 1).

Hubbert went on to predict that World oil production would peak in 1995, assuming current trends of the time were to continue. What he hadn't anticipated, however, were the oil shocks of the 1970's which actually lowered oil demand for a brief period, a shift to natural gas for electricity creation, as well as slightly more fuel efficient vehicles that were result of the OPEC embargoes.

Hubbert's work has spawned a tremendous amount of contemporary research. There are currently many geologists, scientists, and organizations devoted to the study of peak oil and its potential impacts on contemporary, industrialized societies. Still, only very recently has the topic made any major headway within the United States Government. In February of this year (2007), the US Government Accountability Office (GAO) released a report entitled "Crude Oil: Uncertainty about Future Oil Supply Makes it Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production". Despite its rather cumbersome title, the report contains fascinating data pertaining to the future of United States industry, among other topics. A summary of the authors' conclusions:

- The prospect of a peak in oil production presents problems of global proportion whose consequences will depend critically on our preparedness
- While these consequences would be felt globally, the United States, as the largest consumer of oil and one of the nations most heavily dependent on oil for transportation, may be especially vulnerable among the industrialized nations of the world.
- In the past, the private sector has responded to higher oil prices by investing in alternatives, and it is doing so now. Investment, however, is determined largely by price expectations, so unless high oil prices

14 This definition is taken from the Wikipedia entry for Hubbert's Peak, also known as peak oil: http://en.wikipedia.org/wiki/Peak_oil Interestingly enough, this Wikipedia entry is far and away the most thorough and researched primer to the concept. Other, daily-updated, clearinghouse-type websites devoted to the study and discussion of peak oil can be found here: www.energybulletin.net and www.theoildrum.com

[15] Ibid.

[16] Hubbert, M.K. Nuclear Energy and the Fossil Fuels. Presented before the Spring Meeting of the Southern District, American Petroleum Institute, Plaza Hotel, San Antonio, Texas, March 7-8-9, 1956.

are sustained, we cannot expect private investment in alternatives to continue at current levels.

- While public and private responses to an anticipated peak could mitigate the consequences significantly, *federal agencies currently have no coordinated or well-defined strategy to reduce uncertainty about the timing of a peak or to mitigate its consequences.* This lack of a strategy...puts the nation unnecessarily at risk. [17]

The most critical take-home message about this report is that the discussion has now moved from questioning whether or not a peak in oil production is real to how unprepared American society is and what can be done about it. Still, the concept is almost nowhere to be found in the public media, *yet*. Immediately after the release of the GAO report, CNBC aired a 7.5 minute interview with Matthew Simmons, whose research was used for the GAO report.[18] About the report, Simmons states "We are on the verge of replacing the term 'global warming' with the term 'peak oil'." With continued press coverage and research into an immensely difficult issue to deal with, we should finally start to see peak oil garnering the attention it deserves.

The GAO report goes on to give vague and general recommendations for executive action – work on the capacity to effectively monitor global supply and demand to reduce uncertainty (a tremendously difficult venture considering most of the remaining oil is located in territories hostile to the United States) and assess alternative technologies in light of those updated, aforementioned predictions. The report mentions nothing about the scale and scope of the built environment in the United States or how much of American settlement patterns and buildings are predicated on the massive inputs of oil. (Figure 3) These realities must be embedded into the study of how contemporary industries can begin to change and adapt in the future.

Again, what does this have to do with industries sharing things to reduce consumption (industrial symbiosis)? For one, there is a correlation between distance in spatial relationships of American urban settlements, their supporting industrial agglomerations, and oil use (Figure 2).

In a 2003 report issued by the Harvard Institute of Economic Research titled "Cities, Regions, and the Decline of Transport Costs", Ed Glaeser graphically displayed that current industries tend to concentrate at the periphery of high density cities where there is abundant, cheap land for regional to global-scale operations – all supported by abundant, cheap fuel to keep transport costs very low. This view is also echoed in Alan Berger's recent book *Drosscape*; about

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17 United States. Government Accountability Office (GAO). Crude Oil: Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production. Washington D.C.: The GAO, February 2007. Accessed 29 March 2007 from http://www.gao.gov/new.items/d07283.pdf -- All conclusions and recommendations are taken directly from this report, which is essential reading.

18 This video can be viewed here: http://www.youtube.com/watch?v=4fo3sxhBylw&mode=related&search= Matthew Simmons is a chief investment banker for Simmons & Company, International, who wrote a book in 2005 on the Saudi Arabian oil production situation: Simmons, Matthew. Twilight In the Desert. Hoboken, New Jersey: Wiley, 2005.

the vast, horizontally-dispersed urbanization patters in the United States: "one can conclude from the cities researched in this book (Atlanta, Boston Metro, Charlotte-Raleigh-Durham, Chicago, Cleveland, Dallas, Denver, Houston, LA, and Phoenix) that manufacturing establishments are progressively relocating forty to seventy miles outside of their traditional city locations."[19] Figure 4 is an adaptation of images found within Berger's Drosscape, highlighting the types of industrial dispersal that today are commonplace in the United States.

As it currently stands, over 70% of the energy used to run contemporary industries are comprised of oil and natural gas. (Figure 5). In order for this thesis to study the current and future capacity of industrial symbiosis within the context of the United States, it must understand and incorporate the consequences of fuels that are no longer cheap nor abundant, as the trends provided suggest. These trends change the operational structure of any approach aimed and at reducing resource consumption within industries, highlighting the need for change within industries themselves.

### *Other Resources Useful in Understanding the Industrial Situation*

While much of the discussion so far has centered on energy inputs required to run industry, industrial symbiosis (as will be further discussed in the next chapter) often deals with the sharing of resources; be it materials, water, by-product wastes, and so on. The current state of resource availability, distance traveled and their original source location must also be factored into the equation.

The massive quantity of materials used and energy expenditure involved in their creation, transport and construction begs for the question to be asked: what happens to this supply chain if the fundamental energy and resource intensive development patterns begin to change? How can a change begin from limits on materials and energy? Can this finally be the push to make resource-reducing exchange habits a widespread practice?

### *Grounds for Methodology*

The ability to predict the effects of human activities on natural systems is and has always been an inexact science.[20] However, multiple sources are pointing towards signs that vast changes we must deal with lie just ahead. This is not new to societies; critical problems arise frequently when dealing with changes in the built environment. As Lynch points out, "the initial concept of the problem is crucial. Often enough, it is wrong to begin with – the situation so

[19] Berger, Alan. Drosscape: Wasting Land in Urban America. New York: Princeton Architectural Press, 2006. Berger's work contained in this book as well as the practice of Landscape Urbanism will be discussed in greater length in later chapters.

[20] Kibert, Charles J., Jan Sendzimir, and Bradley Guy, Ed. Construction Ecology: Nature as the Basis for Green Buildings. New York: Spon Press, 2002.

poorly understood, the clients so restricted, the aims or the solution envisaged so inappropriate, that nothing can be done except to make things worse."[21] The scope of how the built environment and specifically modern industry adapts to issues posed by peak oil and massive resource consumption over grand distances will demand a response. However, the method or responses in dealing with such a large issue can usually be summarized in two approaches. "One is the view of the basic type of response that is appropriate...seeing a difficulty, one may not try to remove it, but simply seek to understand it and to predict its future course, so that one can adapt, survive, and prosper if possible. At the other end of the scale, one may be convinced that a fundamental change in the rules of the game is essential. Society must make a radical shift. Or, following another alternative, one makes a persuasive model of a habitat or society which is radically better than the present one, but which can be realized gradually."[22]

One such alternative, the practice of industrial ecology, proposes to be this model, balancing technological innovation, human desires, and natural ecological limits in an effort to deal with the realities society now faces. Industrial ecology's background, major thinkers, scale and goals, parallel disciplines and their application to the built environment will be discussed at length in the next chapter.

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[21] Lynch, Kevin. Good City Form. Cambridge, MA: MIT Press, 1984. pg. 42
[22] Ibid.

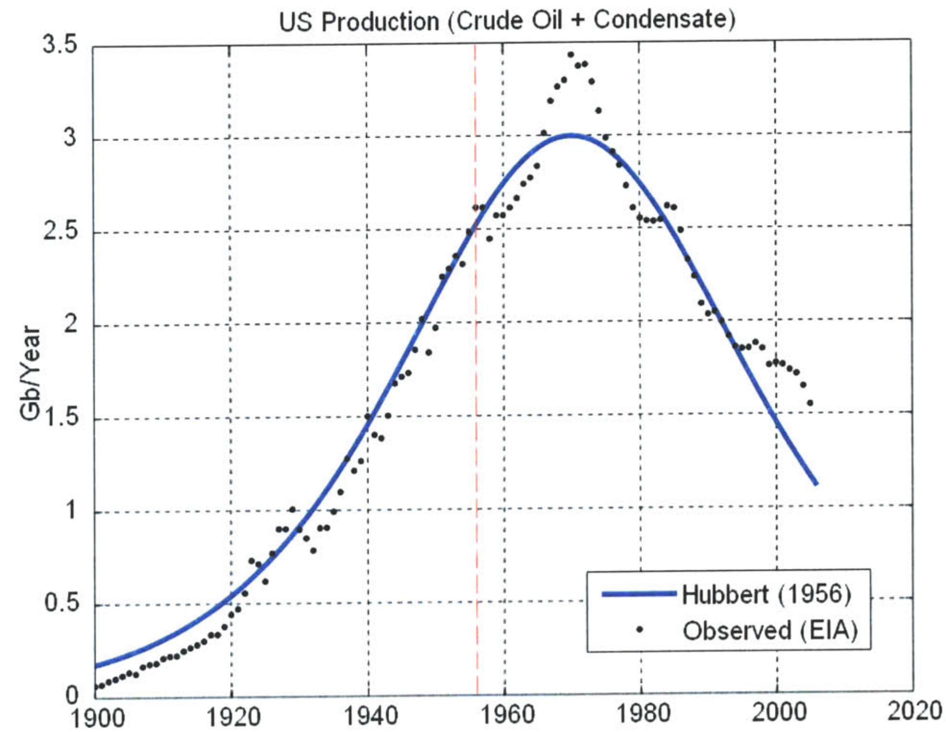


**Figure 1: Hubbert's Prediction of US Oil Production Peak**[23]

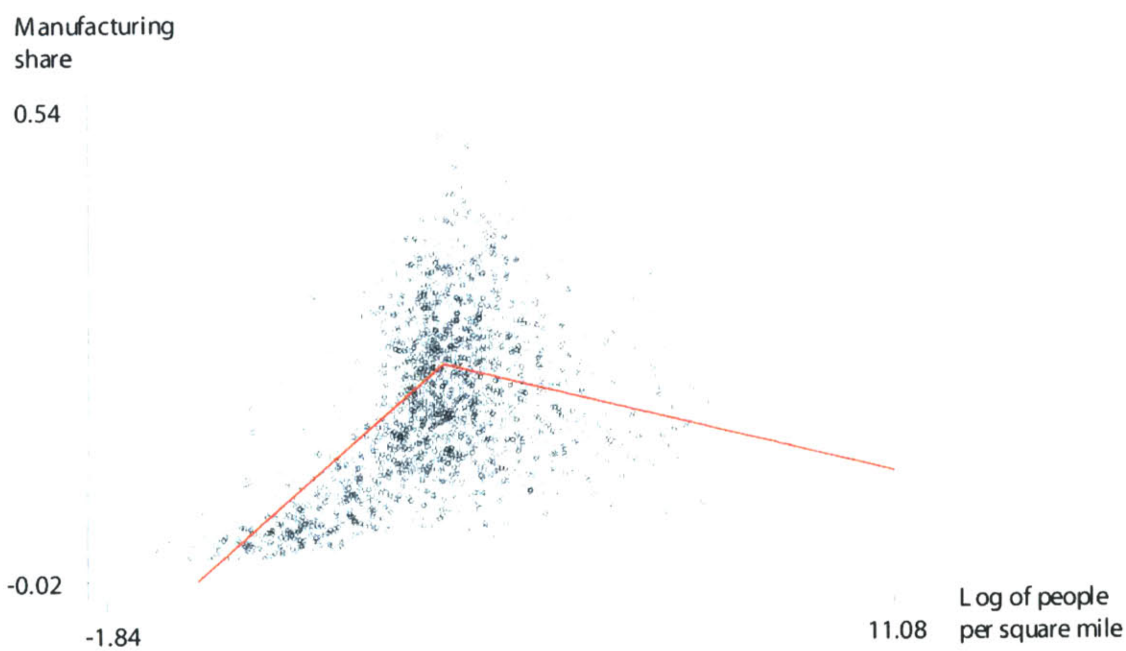


Fig. 14. Manufacturing and density

**Figure 2: Correlation between manufacturing (industry) and population density**[24]

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23 Real production data provided by the Energy Information Administration (EIA) – provider of official energy statistics from the U.S. Government – matched with Hubbert's theoretical bell curve. Image from http://upload.wikimedia.org/wikipedia/commons/5/58/Hubbert_US_high.svg

**Figure 3: Annual U.S. Oil Consumption, by Sector, 1974-2005**

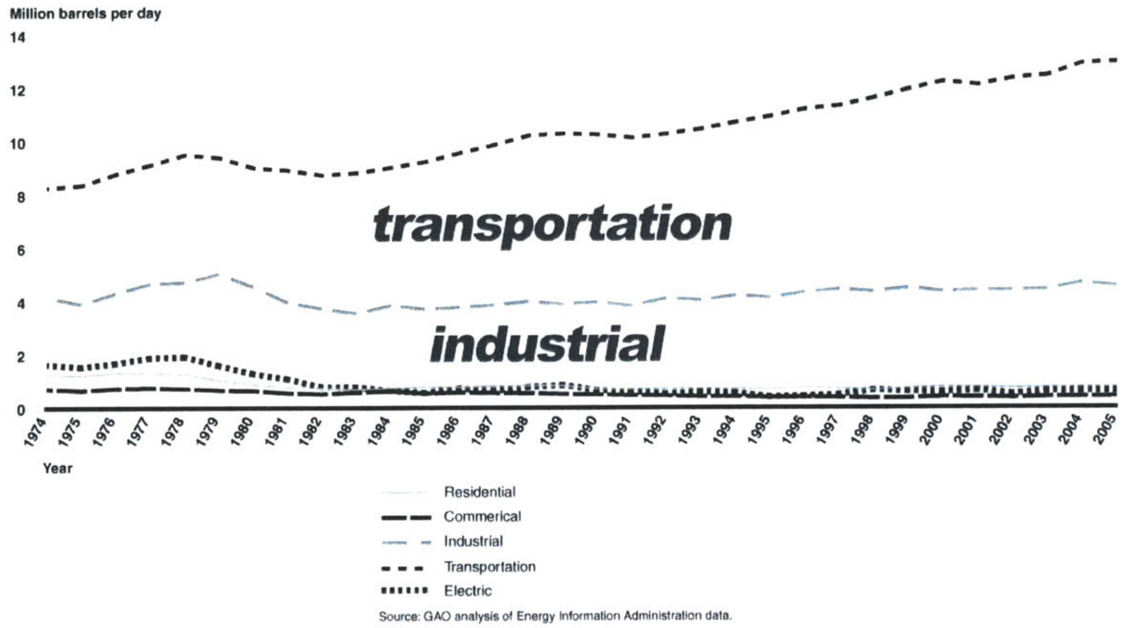



**Figure 3: Oil Consumption by sector in the US displays steady consumption by industry, yet steadily increasing use in the transportation sector, enabling scales and distances between industry and region served to increase Source: GAO report summary of EIA data.[25]**

24 Glaeser, Edward L. and Janet E. Kohlhase. "Cities, Regions, and the Decline of Transport Costs." Harvard Institute of Economic Research. Cambridge: Harvard University, July 2003. Retrieved 18 March 2007 from http://post.economics.harvard.edu/faculty/glaeser/papers.html

25 United States. Government Accountability Office (GAO). Crude Oil: Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production. Washington D.C.: The GAO, February 2007. Accessed 29 March 2007 from http://www.gao.gov/new.items/d07283.pdf pg. 10.

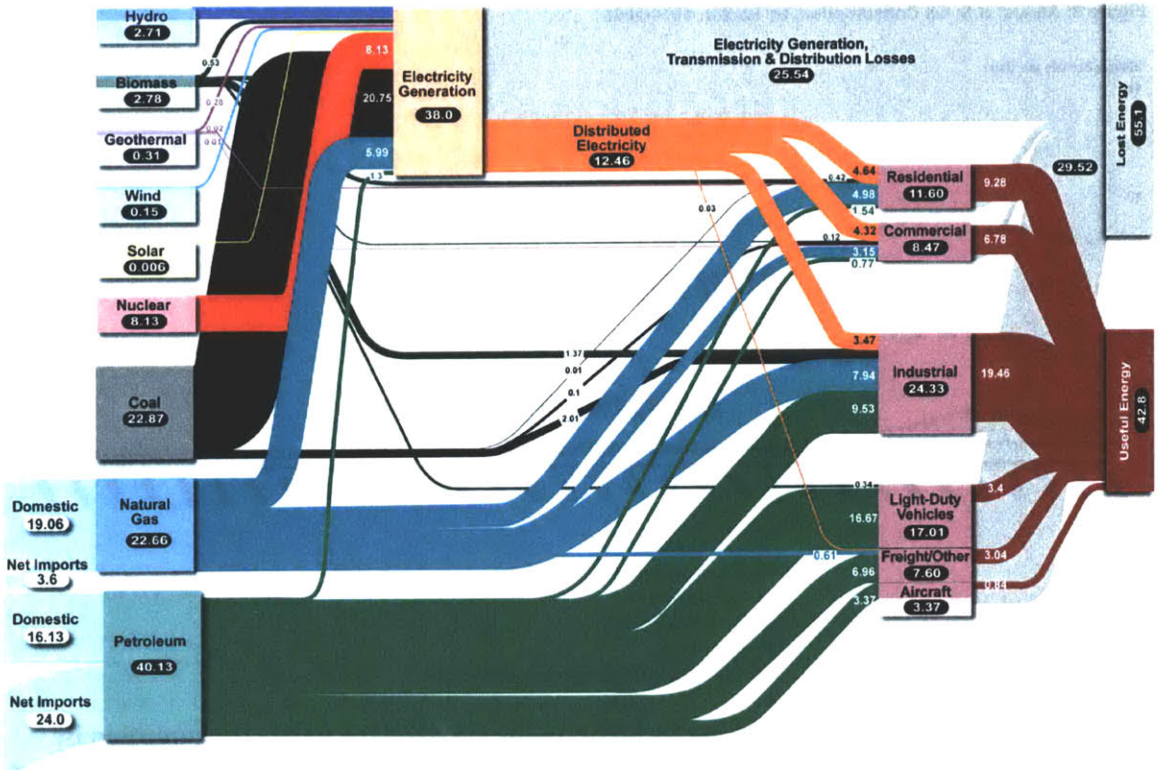



**Figure 4: The complex system of energy flows in the United States in 2005. Units are in quads; 1 quad = 1015 British thermal units = 1.055 exajoules. [Figure prepared by Lawrence Livermore National Labs, University of California, and the U.S. Department of Energy][26]**

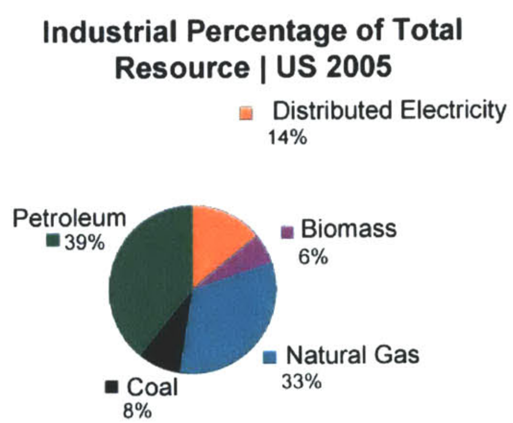
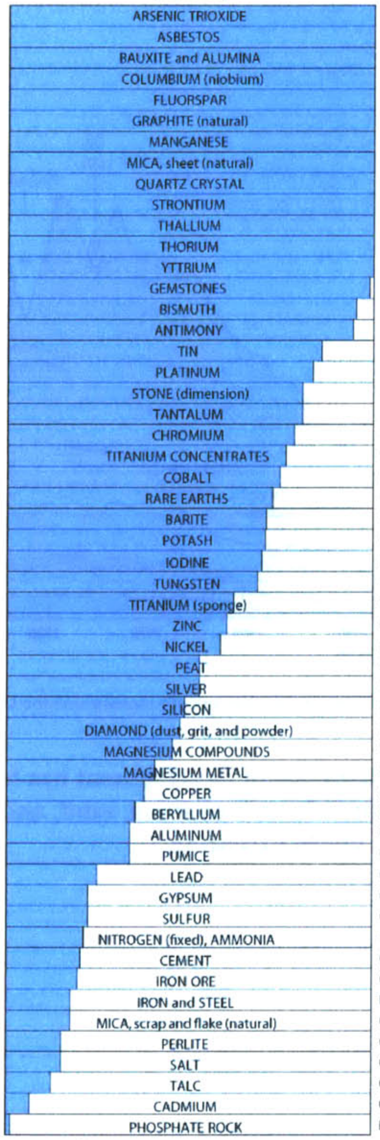



**Figure 5: Percentage of Input Type to Industry in the US in 2005. Source: U.S. Department of Energy**

[26] Image accessed 10 February 2007 from http://www.sciencemag.org/content/vol315/issue5813/images/large/315_796_F1.jpeg

2000 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS



| Commodity [1] | Major Import Trade Sources (1996–99) | Percent |
|---|---|---|
| ARSENIC TRIOXIDE | China, Chile, Mexico | 100 |
| ASBESTOS | Canada | 100 |
| BAUXITE and ALUMINA | Australia, Guinea, Jamaica, Brazil | 100 |
| COLUMBIUM (niobium) | Brazil, Canada, Germany, Russia | 100 |
| FLUORSPAR | China, South Africa, Mexico | 100 |
| GRAPHITE (natural) | China, Mexico, Canada | 100 |
| MANGANESE | South Africa, Gabon, Australia, France | 100 |
| MICA, sheet (natural) | India, Belgium, Germany, China | 100 |
| QUARTZ CRYSTAL | Brazil, Germany, Madagascar | 100 |
| STRONTIUM | Mexico, Germany | 100 |
| THALLIUM | Belgium, Canada, Germany, United Kingdom | 100 |
| THORIUM | France | 100 |
| YTTRIUM | China, Hong Kong, France, United Kingdom | 100 |
| GEMSTONES | Israel, India, Belgium | 99 |
| BISMUTH | Belgium, Mexico, United Kingdom, China | 95 |
| ANTIMONY | China, Mexico, South Africa, Bolivia | 94 |
| TIN | China, Brazil, Peru, Bolivia | 86 |
| PLATINUM | South Africa, United Kingdom, Russia, Germany | 83 |
| STONE (dimension) | Italy, Canada, Spain, India | 80 |
| TANTALUM | Australia, China, Thailand, Japan | 80 |
| CHROMIUM | South Africa, Kazakhstan, Russia, Zimbabwe | 78 |
| TITANIUM CONCENTRATES | South Africa, Australia, Canada, India | 76 |
| COBALT | Norway, Finland, Zambia, Canada | 74 |
| RARE EARTHS | China, France, Japan, United Kingdom | 72 |
| BARITE | China, India, Mexico, Morocco | 71 |
| POTASH | Canada, Russia, Belarus | 70 |
| IODINE | Chile, Japan, Russia | 69 |
| TUNGSTEN | China, Russia, Bolivia | 68 |
| TITANIUM (sponge) | Russia, Japan, Kazakhstan, China | 62 |
| ZINC | Canada, Mexico, Peru | 60 |
| NICKEL | Canada, Norway, Russia, Australia | 58 |
| PEAT | Canada | 52 |
| SILVER | Canada, Mexico, Peru | 52 |
| SILICON | Norway, South Africa, Russia, Canada | 48 |
| DIAMOND (dust, grit, and powder) | Ireland, China, Russia | 47 |
| MAGNESIUM COMPOUNDS | China, Canada, Austria, Australia | 45 |
| MAGNESIUM METAL | Canada, Russia, China, Israel | 40 |
| COPPER | Canada, Chile, Mexico | 37 |
| BERYLLIUM | Russia, Canada, Kazakhstan, Germany | 35 |
| ALUMINUM | Canada, Russia, Venezuela, Mexico | 33 |
| PUMICE | Greece, Turkey, Ecuador, Italy | 33 |
| LEAD | Canada, Mexico, Peru, Australia | 24 |
| GYPSUM | Canada, Mexico, Spain | 22 |
| SULFUR | Canada, Mexico, Venezuela | 22 |
| NITROGEN (fixed), AMMONIA | Trinidad and Tobago, Canada, Mexico, Venezuela | 21 |
| CEMENT | Canada, China, Spain, Venezuela | 20 |
| IRON ORE | Canada, Brazil, Venezuela, Australia | 19 |
| IRON and STEEL | European Union, Canada, Japan, Mexico | 17 |
| MICA, scrap and flake (natural) | Canada, India, Finland, Japan | 17 |
| PERLITE | Greece | 15 |
| SALT | Canada, Chile, Mexico, The Bahamas | 15 |
| TALC | China, Canada, France, Japan | 12 |
| CADMIUM | Canada, Belgium, Australia | 6 |
| PHOSPHATE ROCK | Morocco | 1 |

[1]In descending order of import share

Additional mineral commodities for which there is some import dependency include:

| | |
|---|---|
| Gallium | France, Russia, Kazakhstan, Canada |
| Germanium | Russia, Belgium, China, United Kingdom |
| Indium | Canada, China, Russia, France |
| Mercury | Canada, United Kingdom, Kyrgyzstan, Spain |
| Rhenium | Chile, Germany, Kazakhstan, Russia |
| Selenium | Philippines, Canada, Belgium, Japan |
| Vanadium | South Africa, China |
| Vermiculite | South Africa, China |
| Zirconium | South Africa, Australia |

Figure 6. 2000 U.S. net import reliance for selected nonfuel mineral materials (U.S. Geological Survey 2001a, p. 5.)

**Figure 6: A Vast amount of resources are linked to global-scale exchanges.[27]**

27 Wagner, Lorie A. Materials in the Economy – Material Flows, Scarcity, and the Environment. U.S. Geological Survey. February 2002. Retrieved on 10 February 2007 from http://geology.cr.usgs.gob/pub/circulars/c1221/

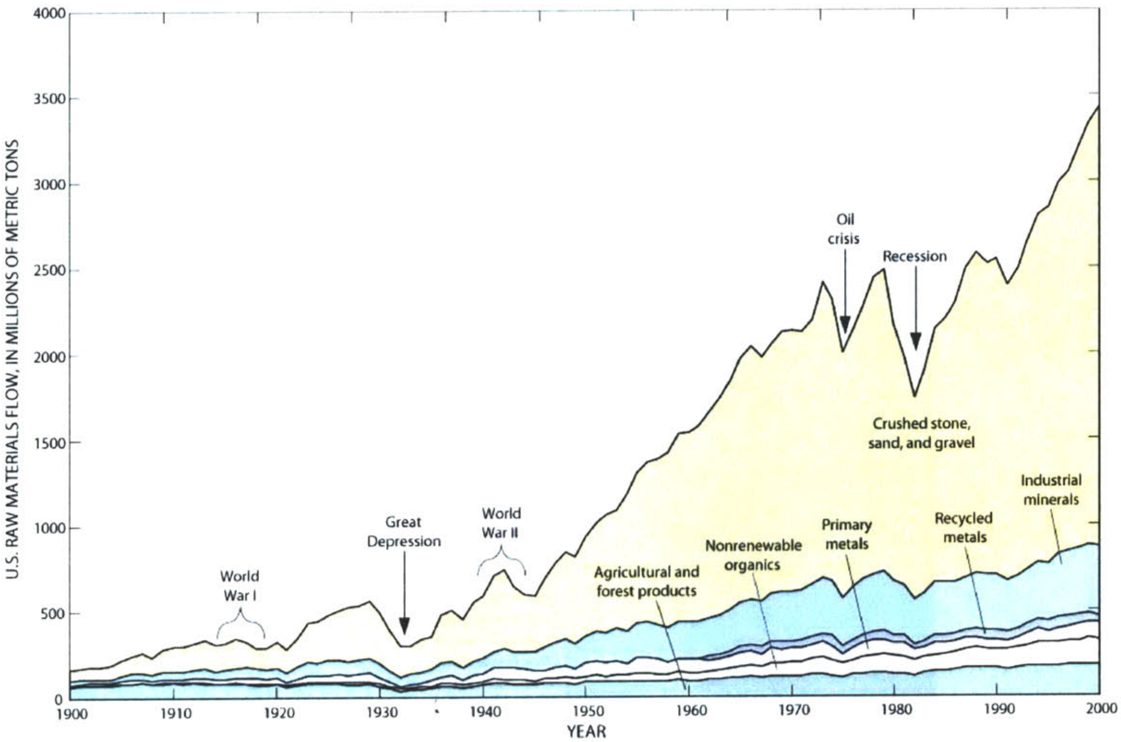
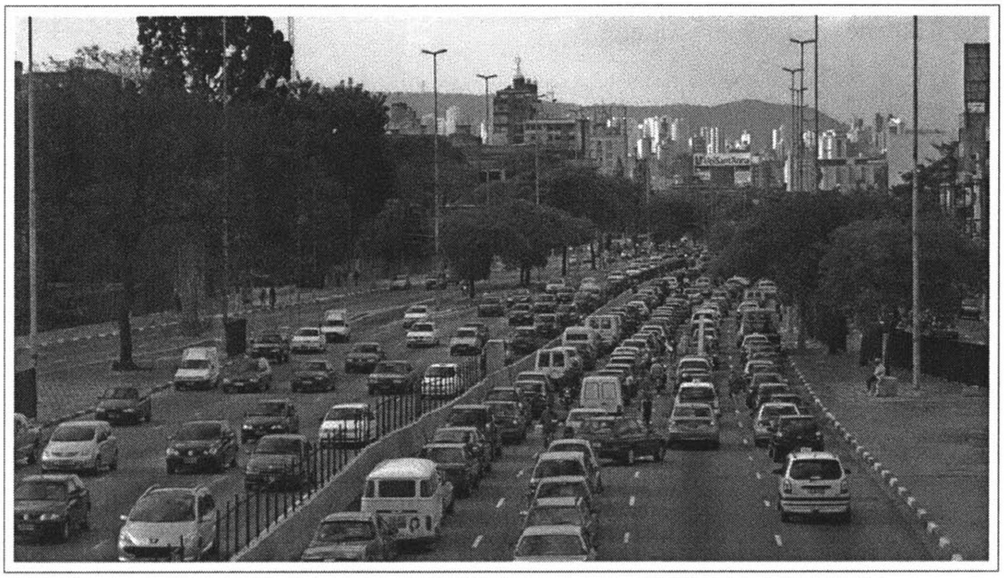


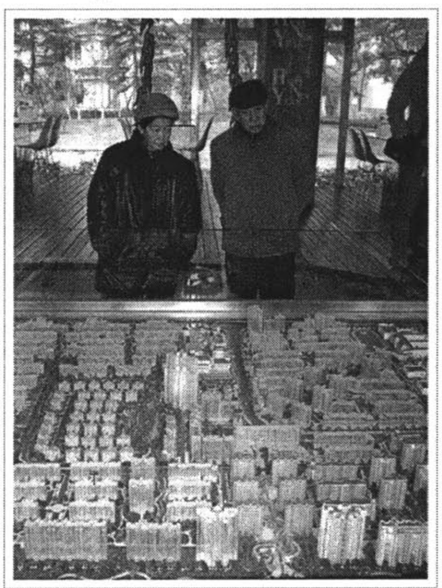

Figure 4. U.S. flow of raw materials by weight, 1900–98. The use of raw materials dramatically increased in the United States througho the 20th century (modifid from Matos and Wagner, 1998, fig. 3).

**Figure 7: The increase in scale and dispersal of development has led to dramatic increases in the consumption of building materials such as stone, sand, and gravel, whose potential re-use is worth exploring[28]**

28 Wagner, Lorie A. Materials in the Economy – Material Flows, Scarcity, and the Environment. U.S. Geological Survey. February 2002. Retrieved on 10 February 2007 from http://geology.cr.usgs.gob/pub/circulars/c1221/



20th Century fixation with limitless growth and mobility: entirely at odds with the resource and energy constraints we face. Location: Sao Paulo, Brazil. Source: Author.



The scale of resilience and adaptation needed by the future city will continue to increase. Location: New Orleans, LA. Source: Author.

Developing Countries following the Western, Energy and Consumption Intensive Development Model. Location: Shanghai, China. Source: Author.

**Figure 8: Precarious Prospects of the Fossil City. Source: Author**

# Chapter Two

*"Beside a stream, don't waste water; even in a forest, don't waste fire wood."*
*- Chinese Proverb*

## The Practice of Industrial Ecology and Industrial Symbiosis: Past to Present

Industrial ecology has been around for quite some time. However, it is still such a strange and relatively unheard of concept outside of select business and academic circles within the United States that almost every publication concerning its practices must offer a general introduction before continuing to any further detail. Industrial ecology, as previously defined, is the shifting of industrial process from linear (open loop) systems, in which resource and capital investments move through the system to become waste, to a closed loop system where wastes become resource inputs for new industrial processes. It has been described "as the marriage of technology and ecology and examines, on the one hand, the environmental impacts of the technological society, and, on the other hand, the means by which technology can be effectively channeled toward environmental benefit."[29] Very rarely does it enter the contemporary discourse of the planning and urban design professions engaged in the shaping our built environment. Industrial ecology must not only become a concept planners and urban designers are aware of, but one they can effectively utilize in practice as well.

This chapter will describe the motivations and inspirations which form the philosophical underpinnings of industrial ecology, its founders and major thinkers, its similarities and convergence with like disciplines, as well as its major strengths and weaknesses. The chapter will also describe industrial symbiosis as a sub-practice within industrial ecology that is applicable at the city scale, including a brief review of the present state of the literature, theory, and practice of industrial symbiosis, and the gaps in current research. The purpose of the chapter is to highlight the merits of industrial ecology and industrial symbiosis to in order understand how these practices can be implemented at a broader scale. An excellent historical overview of industrial ecology (Erkman, 1997) published 10 years ago provides much of the source material for the beginning of this chapter. Information gathered about its development within the last 10 years has been accumulated through many of the sources discussed within.

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29 Chertow, M. "The IPAT Equation and It's Variants: Changing Views of Technology and Environmental Impact." Journal of Industrial Ecology. 2001: 4 (4); 13-29. pg. 21.

## *Enter Industrial Ecology*

The environmental constraints facing society in upcoming years emphasize a conflict between human desires on the one hand, and natural resources on the other, since environmental limits impose caps on perpetual growth in consumption. The concept of industrial ecology can also be seen as two opposite entities placed side by side, an intriguing juxtaposition of concepts normally perceived as incompatible. "We are used to considering the industrial system as separate from the biosphere, with factories and cities on one side and nature on the other, the problem consisting of trying to minimize the impact of the industrial system on what is 'outside' of it: its surroundings, the 'environment'...industrial ecology explores the opposite assumption: the industrial system can be seen as a certain kind of ecosystem." [30] Erkman continues to assert that by 1997 there was no standard definition of industrial ecology (and 10 years later there still is none), yet multiple writings on the topic all fundamentally agree with three key characteristics, as researched by Ray Cote of Dalhousie University:[31] Industrial ecology:

- Is rooted in systems thinking, holistic, and comprehensive in viewing the components of the industrial system and their relations with the biosphere.
- "Emphasizes the complex patterns of material flows within and outside the industrial system, in contrast with current approaches which mostly consider the economy in terms of abstract monetary units, or alternatively energy flows."[32]
- "Considers technological dynamics, i.e. the long term evolution of clusters of key technologies as a crucial (but not exclusive) element for the transition from the actual unsustainable industrial system to a viable industrial ecosystem."[33]

Key events in history have led to the formations of these ideas, molding the foundation of present day industrial ecology.

## *Roots of Industrial Ecology: How did we get here?*

The connection between the patterns of human resource consumption and their detrimental impact on the environment became widely scrutinized during the modern environmental movement era of the 1960's and 70's. Seminal works such as Donella Meadow's "Limits to Growth" first published in 1972 by the Club of Rome began to question expanding populations and the limited capacity of a world with finite resources. Interactions between human and Earth systems were modeled, with a series of scenarios listing severe consequences of the

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[30] Erkman, S. "Industrial Ecology: An Historical View." Journal of Cleaner Production. 5(1-2):1, 1997.
[31] Côté, R. "The Industrial Ecology Seminar: Principles, Topics for Discussion and Dictionary. School for Resource and Environmental Studies, Faculty of Management, Dalhousie University, Halifax, Nova Scotia, Industrial Park as an Ecosystem Project, December 1995
[32] Erkman, S. "Industrial Ecology: An Historical View." Journal of Cleaner Production. 5(1-2):1, 1997
[33] Ibid.

continual growth of human populations and consumption, ultimately suggesting collapse if practices more-aligned with natural systems weren't soon pursued.[34] In total, human and natural systems were viewed counter to one another with little faith put in the ability of technological innovation to reconcile the two. Similarly, recent studies have updated these same warnings and called for even greater action, found in works such as Jared Diamond's 2005 "Collapse: How Societies Choose to Fail or Succeed." These studies demand a response to extremely pressing issues derived from the irresponsive development still currently widespread in modernized society. Diamond lists a wide range of these issues, generally categorized into four groups -- all of which are pertinent to the promise of industrial ecology and the built environment -- natural resource destruction, ceilings on natural resources, wastes, and population:[35]

- The destruction of natural habitats
- The depletion of marine life as a food source
- Rapid loss of wild species
- Soil erosion and degradation
- Overdependence and depletion of primary energy source (fossil fuels)
- Scarcity of potable freshwater
- Limits to photosynthetic capacity
- Unnatural toxic chemicals
- Invasive species of plants and animals
- Greenhouse gas emissions
- Expanding world population
- The expanding environmental footprint of growing population

Each of these demand immediate attention. However, exactly how they are dealt with often becomes a question of new technologies' ability to mitigate our impact vs. changing our habits.

This concept of technology as savior is crucial to the formation of industrial ecology. At the same time of the penning of "Limits to Growth", other scientists in the search for implementable solutions that balance anthropogenic desires and natural capacities were developing means of quantifying human impact on the Earth. One of the most potent attempts to understand this impact resulted in the creation of the I=PAT equation. Originally created from debates between biologists Barry Commoner and the team of Paul Ehrlich and John Holdren, it specifies the human impact (I) on the natural environment is the product of population (P), affluence (A) (or consumption per capita), and technology (T).[36] Up through the 1980's, each of these factors was viewed to

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34 Meadows, Donella, J. Randers, and Dennis Meadows. Limits To Growth: The 30-Year Update. White River Junction, Vermont: Chelsea Green, 2004. Although Donella Meadows has since passed, a 40 year update is planned for release in 2012.

35 Diamond, Jared. Collapse: How Societies Choose to Fail or Succeed. New York: Penguin, 2005. pgs. 486-494.

36 Refer to the following article for an excellent, in depth history and derivation of the IPAT equation: Chertow, M. "The IPAT Equation and It's Variants: Changing Views of Technology and Environmental Impact." Journal of Industrial Ecology. 2001: 4 (4); 13-29

have a negative total impact on the product (the environment), with technology most often considered to exploit resources more effectively. As time passed, it became apparent that something must be done to address the massive environmental issues associated with increasing modern development. At this point in history, people showcased an attempt to merge economy and environment through the defining of 'sustainable development' found in the Brundtland Commission report of 1987.[37] How was society going to achieve this? A fundamental mental switch had to occur -- hailing technology as capable of both facilitating economic growth and drastically reducing environmental impact.[38] The debate still rages as to whether the T of technology in the IPAT equation really offsets growth in population and affluence, or conversely, it only facilitates their overall negative impact. This discrepancy is currently apparent here at MIT, in which a large initiative is underway to "take on the world's energy crisis."[39] Through an established Energy Research Council, half of MIT's work pertaining to the future of energy is related to utilizing technology to advance extraction and consumption paradigms[40] while the other half involves developing new energy technologies such as biofuels-producing microorganisms.[41] Technology's ability to *reduce the demand* for energy is rarely discussed, however.

While publications like "Limits to Growth" and the I=PAT equation were arguing for the limits and repercussions of growth to be realized, major advances in the sciences of ecology were also underway. The pioneering work of Eugene Odum helped increase our understanding of the interconnectedness of the natural world, especially in terms of matter and energy exchange through ecosystems as studied within ecosystem ecology and succession. Odum promulgated the idea that the Earth was a woven set of ecosystems which needed to be reconciled with human systems.[42] Odum's 1969 comment "an understanding of ecological succession provides a basis for resolving man's conflict with nature"[43] clarifies the framework for which industrial ecology, formally recognized 20 years later, would build upon.

Yet, industrial ecology as an idea emerged far before being formally recognized as a means of reconciling this conflict between man and nature. As clarified by Erkman, both Belgium and Japan had examined the idea of industrial ecology throughout the 1970's and 80's. An interdisciplinary group of Belgian intellectuals set out to understand their economy in terms of materials and

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[37] Chertow, M. "The IPAT Equation and It's Variants: Changing Views of Technology and Environmental Impact." Journal of Industrial Ecology. 2001: 4 (4); 13-29

[38] Ibid.

39 An institute-wide initiative established in mid-2005. http://web.mit.edu/newsoffice/2005/energy-0608.html Accessed 10 October 2005.

40 "MIT is pioneering new approaches to enhanced petroleum recovery from existing reservoirs and to oil and natural gas production in ultra-deep water and other unconventional reservoirs." http://web.mit.edu/erc/research/where.html For an example, see MIT's project on "The Future of Coal" http://web.mit.edu/coal/ Accessed 02 April 2007.

41 http://web.mit.edu/erc/research/where.html#bio Accessed 02 April 2007.

[42] Odum, Eugene P. Fundamentals of Ecology. Collingwood, ON: Saunders, 1969.

[43] Odum, Eugene P. "The Strategy of Ecosystem Development." Science. 1969 Apr 18; 164(877):262-70.

energy rather than abstract monetary units in 1983.[44] Their analysis arrived at a very early operational definition of industrial ecology, highlighting the convergence of industrial activity and the science of ecology:

> "To include industrial activity in the field of an ecological analysis, you have to consider the relations of a factory with the factories producing the raw materials that it consumes, with the distribution channels it depends on to sell its products, with the consumers who use them...In sum, you have to define industrial society as an ecosystem made up of the whole of its means of production, and distribution and consumption networks, as well as the reserves of raw material and energy that it uses and the waste it produces...A description in terms of circulation of materials or energy produces a view of economic activity in its physical reality and shows how society manages its natural resources."[45]

Concluding their analysis, the Belgians found the current industrial practice guilty of not utilizing wastes, being intensely energy in-efficient, and pollution generating – all of which are central issues dealt with in industrial ecology. The Japanese arrived at industrial ecology through a different route in the 1970's – geography. Japan is isolated and needed means of dealing with this geographic separation; they "needed to become less dependent on the consumption of materials and based more on information and knowledge."[46] Prompted by the OPEC oil embargoes of 1973 and 1979, Japan launched multiple projects to increase energy efficiency and reduce greenhouse gas emissions. "A basic principle underlies this strategy: replace material resources with technology. This is why technological dynamics is at the heart of Japanese thinking on industrial ecology."[47] While these initiatives were underway industrial ecology remained relatively unknown as an identifiable practice or theory. However, the late 1980s and early 90s saw a collection of major worldwide summits on how to deal with the conflict of human and natural systems, such as 1987s Brundtland report on sustainable development and 1992ss Rio de Janeiro summit. Mentalities were shifting; the time was ripe for change.

In September 1989, Robert Frosch and Nicholas Gallopoulos, both employees of General Motors at the time, authored an article titled "Strategies for Manufacturing" for *Scientific American*. In it, they suggested the linking of industrial systems more closely to the operation of natural systems. All of their work was based on the resource and environmental constraints previously mentioned, as well as writings like "Limits to Growth."

> "[Trends regarding population and resources] lead to the recognition that the traditional model of industrial activity – in which individual

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44 Erkman, S. "Industrial Ecology: An Historical View." Journal of Cleaner Production. 5(1-2):1, 1997

45 Erkman, S. "Industrial Ecology: A Historical View." Journal of Cleaner Production. 5(1-2):1, 1997.

46 Ibid.

47 Ibid.

> manufacturing processes take in raw materials and generate products to be sold plus waste to be disposed of should be transformed into a more integrated model: an industrial ecosystem. The industrial system ecosystem would function as an analogue of biological ecosystems. (Plants synthesize nutrients that feed herbivores, which in turn feed a chain of carnivores whose wastes and bodies eventually feed further generations of plants.) An ideal industrial ecosystem may never be attained in practice, but both manufacturers and consumers must change their habits to approach it more closely if the industrialized world is to maintain its standard of living – and the developing nations are to raise theirs to a similar level – without adversely affecting the environment."[48]

The same issues of wastes, resources, and pollution later raised by Diamond were being proposed as the centerpiece of a new paradigm of industrial processes.

> "We were concerned with problems of waste, with the value of materials, and with the control of pollution. At the same time, we were discussing the natural world and the nature of biological and ecological systems. There was a natural ferment of thinking about the human world, its industries, and its waste products and problems and about the coupling of the human world with the rest of the natural world."[49]

While not necessarily offering any new ideas, Frosch and Gallopoulos's article opened the floodgates to what is the current day practice of industrial ecology.

From its roots within multiple disciplines and implementation across a variety of applications, industrial ecology is now promoted by a professional organization known as the International Society for Industrial Ecology.[50] It also has a variety of peer-reviewed journals serving as outlets for discourse and ideas, such as the Journal of Industrial Ecology (MIT Press), the Journal of Cleaner Production, and Progress in Industrial Ecology (an international journal).[51]

### *The divisions of industrial ecology*

Industrial ecology is a term that encompasses several sub-practices, operating at different scales, which aim to reduce human impact on the environment:

- **Design for Environment (DFE)** – deals with incorporating the environmental impact of any given product from the onset of its creation, searching for the most minimally intrusive means of

[48] Frosch, Robert A. and Gallopoulos. "Strategies for Manufacturing". N. Scientific American. 261 (3), 144-153: 1989.
[49] Frosch, Robert A. Proceedings of the National Academy of Sciences of the United States of America. 1992, 89, 800-803.
50 International Society for Industrial Ecology: www.is4ie.org Accessed 10 October 2006.
51 Journal of Industrial Ecology: http://www.mitpressjournals.org/loi/jiec Progress in Industrial Ecology: https://www.inderscience.com/browse/index.php?journalID=55 Journal of Cleaner Production: http://www.environmental-expert.com/magazine/elsevier/jclepro/

production Example: Biodegradable and/or re-usable packaging design.

- **Life Cycle Assessment (LCA)** – the assessment of the environmental impact of any given product or service over the course of its entire lifespan, in order to choose the most environmentally sensitive. Example: Cradle-to-grave analysis of the automobile.
- **Materials Flow Analysis (MFA)** – the accounting and tracking of any number of materials through a production or parameter of interest Example: tracking of every aspect of water use within a city
- **Industrial Symbiosis** – The physical exchange of materials, energy, water, and/or by-products between industries. Case studies of industrial symbiosis will be discussed in the next chapter.
- **Urban Metabolism** – The measure of all input and output flows of resources, and energy at the scale of the city. Example: complete material flow analysis for the city of Lisbon.

Multiple divisions are cross-cutting and self-supporting, such as design for environment and life cycle assessment, or part/whole, such as materials flow analysis and urban metabolism. In general, two major themes can be categorized from the above, Eco-Industrial parks (Industrial symbiosis), and the dematerialization of the economy.[52] This thesis, albeit including the utilization of each component, is primarily focused on the firewalls prohibiting large scale deployment of such industrial symbiosis techniques in the United States.

Industrial ecology recognizes these firewalls, and as such has aligned itself with similar emerging disciplines; their focus reinforcing one another and all incorporating some ecological viewpoint. Their co-existence is essential to the widespread dissemination and success of industrial symbiosis. These two major supportive disciplines are ecological economics and the concept of ecological footprint. Ecological economics is based on much of the same concepts as industrial ecology in that it attempts to reconcile human activity with the natural world by realizing that "much economic activity is really the material expression of human ecological relationships."[53] In contrast to neo-liberal economics, it suggests an economic system based on the second law of thermodynamics – the entropic equilibrium over time – accepting that if "humans are ecological entities then we must also accept that human economic activity is governed by the second law. The ecological economics framework better equips us to analyze cities – the economic engines of national economies – as ecological entities."[54] In order for resources to be even considered for exchange at a large scale, their "true cost" must be understood to clarify the economic value of such actions.

52 Erkman, S. "Industrial Ecology: A Historical View." Journal of Cleaner Production. 5(1-2):1, 1997.
53 Rees, William E. "Understanding Urban Ecosystems: An Ecological Economics Perspective." Understanding Urban Ecosystems: A New Frontier for Science and Education. Ed. Alan Berkowitz, Charles Nilon, Karen Hollweg. New York: Springer, 2002. 115-136.
54 Ibid.

Ecological economics offers the framework for achieving this, thus bolstering industrial ecology and symbiosis.

Industrial ecology is also responding to ecological footprint analysis, the measure of humanity's demand on the biosphere in terms of the area of biologically productive land and sea required to provide the resources we use and to absorb our waste.[55] Intended to be a quantification of our overall environmental impact (refer to the previously discussed I=PAT equation), recent ecological footprint studies provide the evidence to support Diamond's statements that we are facing major consequences due to our consumptive practices. Images at the end of this chapter released in 2006 highlight we are currently estimated to be living above the carrying capacity of the Earth even at present modes of lifestyle, have severely lowered the living planet index (the measure of World biodiversity), and have three general future scenarios facing us, displayed in figure 11. These findings demand industrial ecology's application to reconcile human and natural systems if we are to avoid the dire consequences.

### *Strengths, Weaknesses, Praise, and Criticisms*

Industrial ecology certainly offers a promising option in dealing with the numerous challenges facing American society. However, it is not without flaws. Industrial ecology has had a series of critical questions left unanswered from its inception, best listed by Jesse Ausubel in reflections on the first national colloquium on the topic held in 1991. He states as major issues:

- Do socio-technical systems have long-range environmental goals?
- How is the concept of industrial ecology useful and timely?
- What are environmental technologies?
- Is there a systematic way to choose among alternatives for improving the ecology of technologies?
- What are ways to measure performance with respect to industrial ecology?
- What are the sources and rates of innovation in environmental technologies?
- How is the market economy performing with respect to industrial ecology?
- What will be the effect of the ecological modernization of the developed nations of the North on the developing nations of the South?
- How can creative interaction on environmental issues be fostered among diverse social groups?
- How must research and education change? [56]

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[55] Wackernagel, M. and W.E. Rees. Our Ecological Footprint: Reducing Human Impact on the Earth. Gabriola Island, BC: New Society Publishers, 1996.

56 Ausubel, Jesse H. "Industrial Ecology: Reflections on a Colloquium." National Academy of Sciences. 89; 879-884: 1992.

Larger issues have been raised about the efficacy of industrial ecology to deal with the conflict between human and natural systems. Does industrial ecology (more specifically industrial symbiosis) prolong the use of dying, outdated industries as opposed to foster the development of new ones? "[Does] the field ignore the deeper environmental problems of consumerism, advanced industrial capitalism, and dependence on fossil fuels?"[57] Each of these questions must be considered when envisioning the implementation of industrial symbiosis and ecology at the city scale, with the second point about fossil fuels proving especially crucial for the study of how industrial production, distribution, and consumption will change over time. Only if these questions are appropriately addressed can one begin to understand how industrial ecology and symbiosis can serve as viable tools to reconcile human intentions and their detriments to natural systems.

### The Present state of Industrial Symbiosis: Capacities

There are currently two conceivable operational scales of industrial symbiosis. The first, historical-driven symbiosis type is based on the physical proximity of firms, best defined as "traditionally separate industries [engaged] in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. *The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity.*"[58] This type of industrial symbiosis can be considered as non-virtual; it involves physically linked firms exchanging any of the aforementioned resources, materials and/or energy. Realizing this co-location and proximity of compatible firms is often a limiting factor in today's globalized and spatially dispersed industrial world, (especially in the United States). Recent attempts at industrial symbiosis have expanded to non-virtual exchanges; the sharing of resources across vast geographic distances enabled by cheap transportation costs. Dr. Marian Chertow, the industrial symbiosis expert at Yale University responsible for the above non-virtual definition, has also since expanded her description of symbiosis. "Industrial symbiosis...is principally concerned with the cyclical flow of resources through networks of businesses as a means of cooperatively approaching ecologically sustainable industrial activity. Industrial symbiosis, then, has the potential to redefine industrial organization by pushing companies to think *beyond individual firm boundaries to a broader systems level.*"[59] This critical distinction between the scales of non-virtual and virtual symbiosis is embedded throughout the rest of the work contained in this thesis.

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[57] Andrews, Clinton J. "Putting Industrial Ecology into Place: Evolving Roles for Planners." American Planning Association Journal. 1999: 65(4); 364-375.
[58] Chertow, Marian R. "Industrial Symbiosis: Taxonomy and Literature." Annual Review of Energy and Environment. 2000. 25: 313-37.
[59] Chertow, Marian R. and D. Rachel Lombardi. "Quantifying Economic and Environmental Benefits of Co-Located Firms." Environmental Science and Technology. 2005: 39 (17); 6535-6541.

The theory of industrial symbiosis has been discussed for some time, its implementation offers a mixed bag of results. Currently, a large amount of work within industrial ecology/symbiosis is devoted to data collection and resource mapping; getting a better quantitative picture of detailed material and resource input and output flows at various scales. Other analyses focus on the economic and financial benefits of industrial symbiosis, expressing the importance for hard numbers to make such exchanges an attractive option for typical, non-linked industries.[60]

Still, many areas of industrial ecology and symbiosis are in need of further study. A comprehensive listing of such areas can be found in Charles Kibert's 2002 book titled *Construction Ecology*. In it, Kibert highlights several key zones pertinent to advancing industrial ecology and symbiosis as they relate to our built environment. A few examples quoted from the text:

Industrial Ecology

- Changes needed to create an environmentally responsible industrial ecosystem must be intelligible to the population of the particular industry.
- A new paradigm for industry is the collaboration of actors versus the possession of technical expertise.
- Reducing consumption is more important than increasing production efficiency as the change agent for industrial ecology.

Design

- Architects need to have a strong, fundamental education in ecology.
- [Need to] integrate risk assessments of long-term patterns (climate change, fossil fuel declines, water shortages) with processes that determine where, when, and how buildings are built, used, and recycled.

General

- Government officials and code-writing bodies need more education.
- Long-term memory is weak in human systems. [61]

This thesis will focus specifically on how these principles listed above, specifically the integration of risk assessments of long-term patterns, affect the future implementation of industrial symbiosis in the United States context. In order to understand where we are going we need to examine existing case studies of industrial symbiosis, the intent of the following chapter.

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[60] Ibid. Refer to Chertow's "Quantifying Economic and Environmental Benefits of Co-Located Firms" for a recent (2005) look at this process applied to the symbiosis of a Puerto Rican exchange network.

[61] Kibert, Charles J., Jan Sendzimir, and Bradley Guy, Ed. Construction Ecology: Nature as the Basis for Green Buildings. New York : Spon Press, 2002.

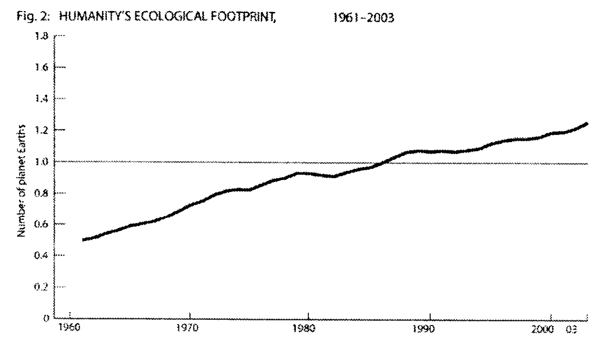


**Figure 9: Humanity's Ecological footprint of 2003 is beyond Earth's carrying capacity and growing.**[62]

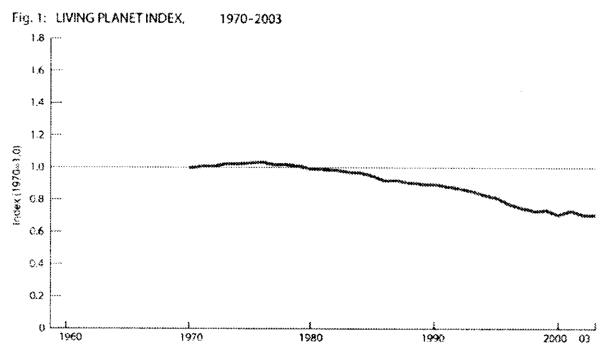


**Figure 10: Living Planet Index: In accordance to a growing ecological footprint, the World's biodiversity is decreasing**[63]

62 World Wildlife Fund. Living Planet Report 2006. Retrieved on 23 February 2007 from http://assets.panda.org/downloads/living_planet_report.pdf

63 Ibid.

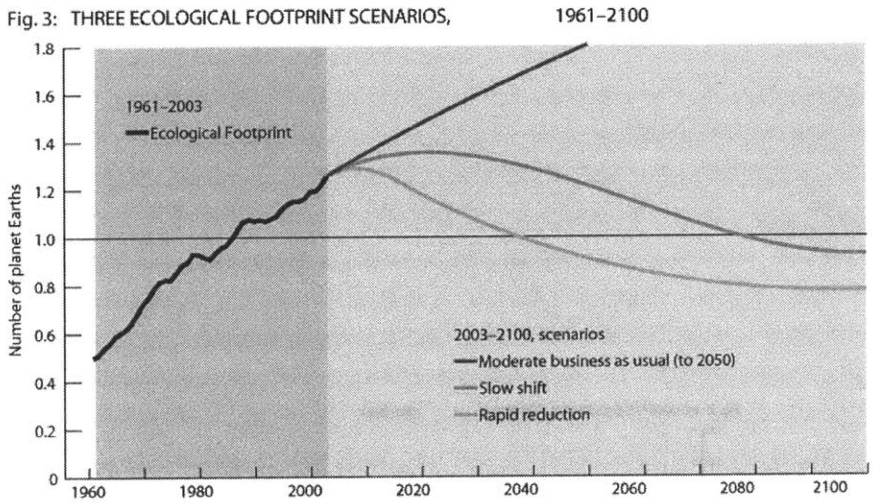


**Figure 11: Paths to choose in the future in dealing with living beyond capacity[64]**

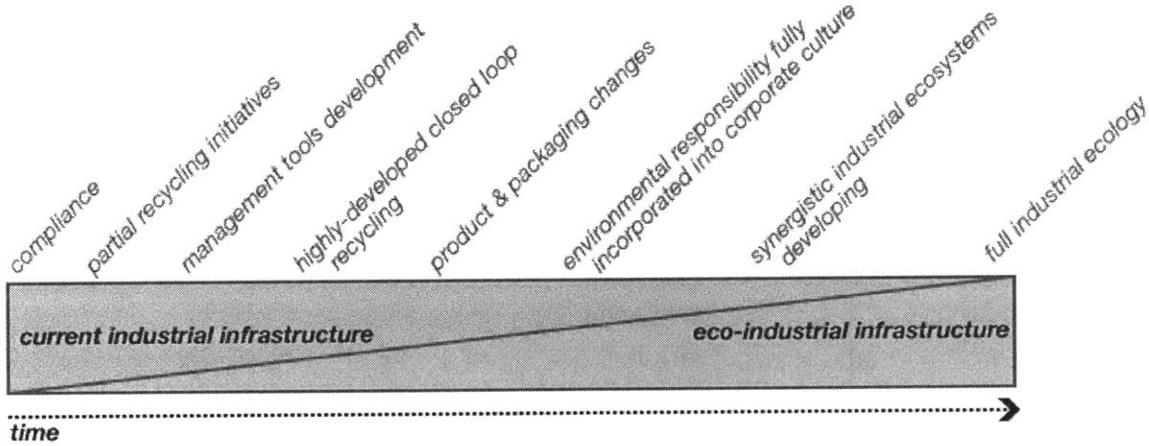


**Figure 12: Scale of Industrial Ecology goals over time.[65]**

[64] Ibid.
65 Image adapted from Arthur D. Little's graphic found here: http://newcity.ca/Pages/industrial_ecology.html Accessed 22 October 2006.

# Chapter Three

*"The message of the Rio Summit that resources are finite obviously has not reached us yet. In other words: waste management, waste exchange, and recycling systems will not be sufficient to realize the promise of a circular economy. We have to move eco-industrial parks beyond the waste issue; identifying the other opportunities for resource efficiency...we can hope for some spillover effects between the eco-city movement and eco-industrial parks."*
*- Andreas Koenig*

*"Industry is a better horse to ride than genius."*
*- Walter Lippmann*

## Case Studies of Industrial Symbiosis

The root of industrial symbiosis is material exchange. In her 2000 article "Industrial Symbiosis: Literature and Taxonomy" Chertow clarifies 5 scales of exchange derived from examining eco-industrial parks. They are categorized in increasing levels of scale.

Type 1: Through Waste Exchanges
Type 2: Within a Facility, Firm, or Organization
Type 3: Among firms Co-located in a defined eco-industrial park
Type 4: Among Local firms that are not co-located
Type 5: Among firms organized "virtually" across a broader region

"By definition, types 3-5 offer approaches that can readily be identified as industrial symbiosis."[66]

This thesis is concerned with symbiosis types 3 through 5 as they operate at the metropolitan level and provide examples of how to analyze symbiosis within the context of urbanization patterns and their driving forces. In this

[66] Type classifications taken directly from Chertow, Marian R. "Industrial Symbiosis: Taxonomy and Literature." Annual Review of Energy and Environment. 2000. 25: 313-37.

chapter, six case studies are displayed beginning with the first realized form of symbiosis at Kalundborg, Denmark to the recently-established national scale operation of the National Industrial Symbiosis Programme (NISP) in the United Kingdom. There are examples of virtual and non-virtual exchanges, retrofits and networks developed from scratch, from locations in the United States and abroad. Information for these case studies is derived from a variety of sources including journal articles, books, promotional web-sites, theses, site visits and personal interviews. The goal of the chapter is to provide insight into the many opportunities and constraints to the successful implementation of symbiotic networks in the United States. From there, we can better understand how the industrial symbiotic network can adapt within cities faced with changing resource and energy flows in the near future, how the specifics of exchange are affected, how planners can facilitate adaptation and how they might achieve it.

### *Case Study One: The Original Symbiosis Network of Kalundborg, Denmark*

The industrial symbiosis at Kalundborg, Denmark is widely touted as the first organized, contemporary form of resource exchange in the world. It is currently a co-operation between six processing companies, one waste handling company and the Municipality of Kalundborg (population approx. 20,000).[67]

> "The philosophy behind the Symbiosis is that the six companies: Energy E2 Asnæs Power Station, the plasterboard factory BPB Gyproc A/S, the pharmaceutical plant Novo Nordisk A/S, the enzyme producer Novozymes A/S, the oil refinery Statoil A/S, Bioteknisk Jordrens Soilrem A/S as well as the waste company Noveren I/S and Kalundborg Municipality - exploit each other's residual or by-products on a commercial basis. The Symbiosis co-operation has developed spontaneously over a number of decades and today comprises some 20 projects. All projects are environmentally and financially sustainable."[68]

The industrial symbiosis at Kalundborg has been extensively documented. The first major publication explaining its history, exchanges, and communication networks was published in a 1995 MIT master's thesis by Nicholas Gertler titled "Industrial Ecosystems: Developing Sustainable Industrial Structures." Kalundborg is so widely written about as a model not only because it is the first contemporary example of such exchanges taking place, but also because it effectively conveys the idea of an industrial system functioning in closed-loop, ecological fashion, expressing the potency of industrial ecology. Unfortunately, it has many characteristics that make its success extremely context dependent – it cannot be replicated as a model in most other highly dispersed, non-communicative, non-regulated industrial environments.

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67 Symbiosis Institute. "Industrial Symbiosis: Exchange of Resources." Accessed 20 October 2006 from http://www.symbiosis.dk/

68 Ibid.

The exchanges at Kalundborg were initiated as a cooperative response to an environmental constraint and evolved slowly over the past four-plus decades. "The history of Kalundborg really began in 1961 with a project to use surface water from Lake Tisso for a new oil refinery in order to save the limited supplies of ground water. The City of Kalundborg took the responsibility for building the pipeline while they refinery financed it."[69] Over the next few decades open communication, collaboration, regulations on the disposal of waste, and spatial proximity enabled a diverse mix of resource exchanges to come on-line establishing what its founders dubbed an "industrial symbiosis." The evolution of these exchanges is documented in the set of images at the end of this case study.

### *Spatial Network of Non-Virtual Exchanges*

The physical proximity of the firms engaged in material exchanges enables such resources like water to be used by other industries, as well as excess steam heat for district heating in the Municipality of Kalundborg. The critical distance on these types of exchanges is roughly 2 miles. Kalundborg boasts a diversity of conduits to enable such exchanges ranging from complex piping systems, water transport, and roadway. Again, this spatial structure of these industrial land uses embedded within residential fabric is a very unique situation, difficult to replicate in the United States or anywhere else.

### *Quantified Benefits of Exchange*

The industrial symbiosis at Kalundborg has been tracked for both its environmental and economic benefits. Economically, the gains have been:[70]

- The investment in material and energy exchanges so far has been estimated at $75 million through 1998. (USD)
- The partners estimate they've saved $160 million so far. (USD)
- Average return on investment time is 5 years.

From the standpoint of resources, materials, and energy, the exchanges greatly reduce consumption rates and waste output.

Kalundborg has been hailed as proof that industrial symbiosis and ecology can make a positive impact on both economic and environmental systems. Still, it must be understood for the precise reasons why it works – open communication between firms fostered over time, physical proximity for the types of resources exchanged, and regulations that encourage sharing wastes as opposed to disposal. These characteristics are extremely difficult to implement elsewhere despite the numerous attempts to do so.

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69 Christensen, J. Proceedings of the Industry and Environment Workshop, held at the Indian Institute of Management, Ahmedabad, India, 1999.
70 Lowe, Ernest A. Eco-Industrial Handbook for Asian Developing Countries. Asian Development Bank, 2001. Retrieved on 16 January 2007 from http://www.indigodev.com/Handbook.html

There is very little discussion within the industrial ecology field about the relatively low adaptability of an exchange network built on a coal-fired power station and oil refinery as its main components. What happens when these fossil inputs change? It seems this system has little built-in resilience for such a future. However, the industrial symbiosis at Kalundborg is the best example we have for understanding non-virtual exchanges between firms and urbanized areas executed extremely well.

### *Value added by Planner*

Although the Kalundborg model has been attempted to be replicated many times over by planners, its sheer success is rooted in the "hands-off" bottom-up, self-organizing nature of exchanges facilitated by the participating firms. However, regulations pertaining to the disposal of wastes created incentives for the firms to participate in the exchanges, and planners advocate for these regulations on a normal basis. As such, planners attempting to recreate this from a top-down "planned" approach have failed, as displayed by the next example.

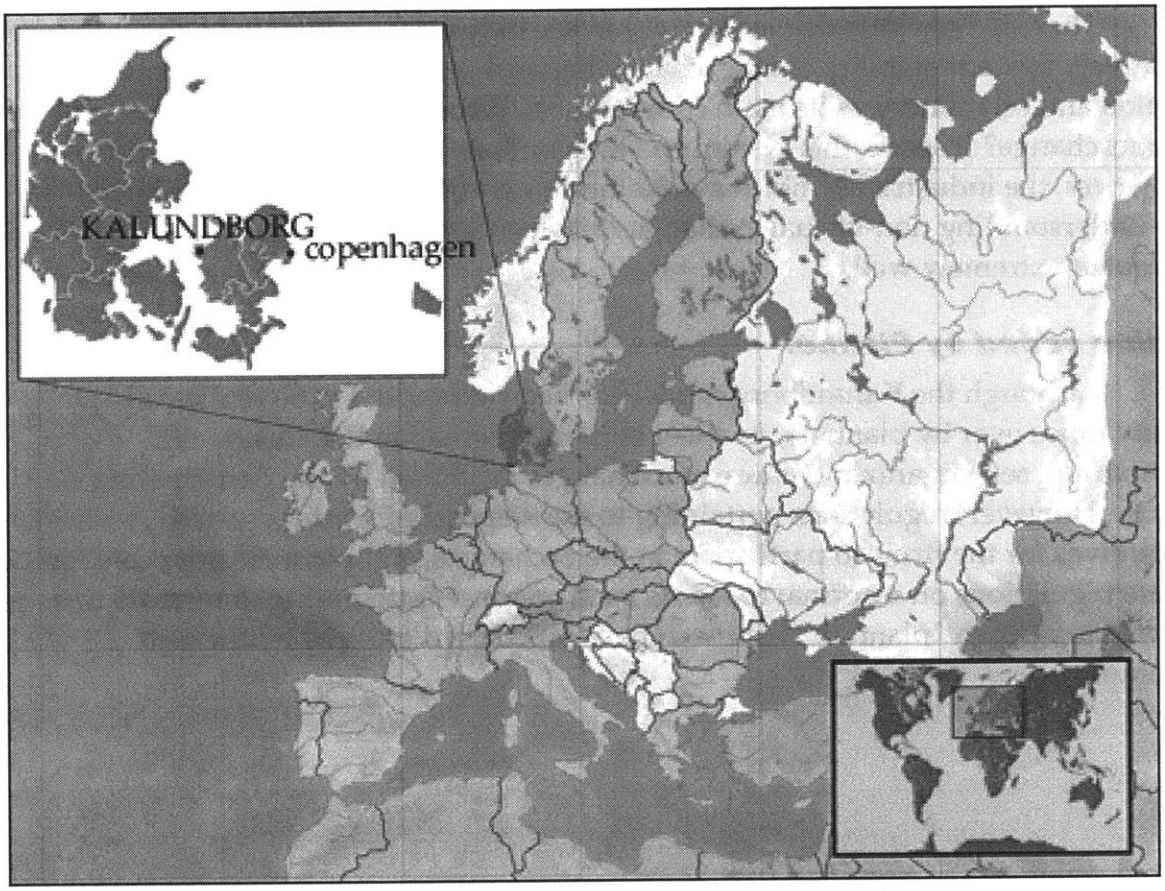


**Figure 13: Kalundborg is about 60 miles west of Copenhagen, Denmark[71]**

[71] Image adapted from www.wikipedia.org.

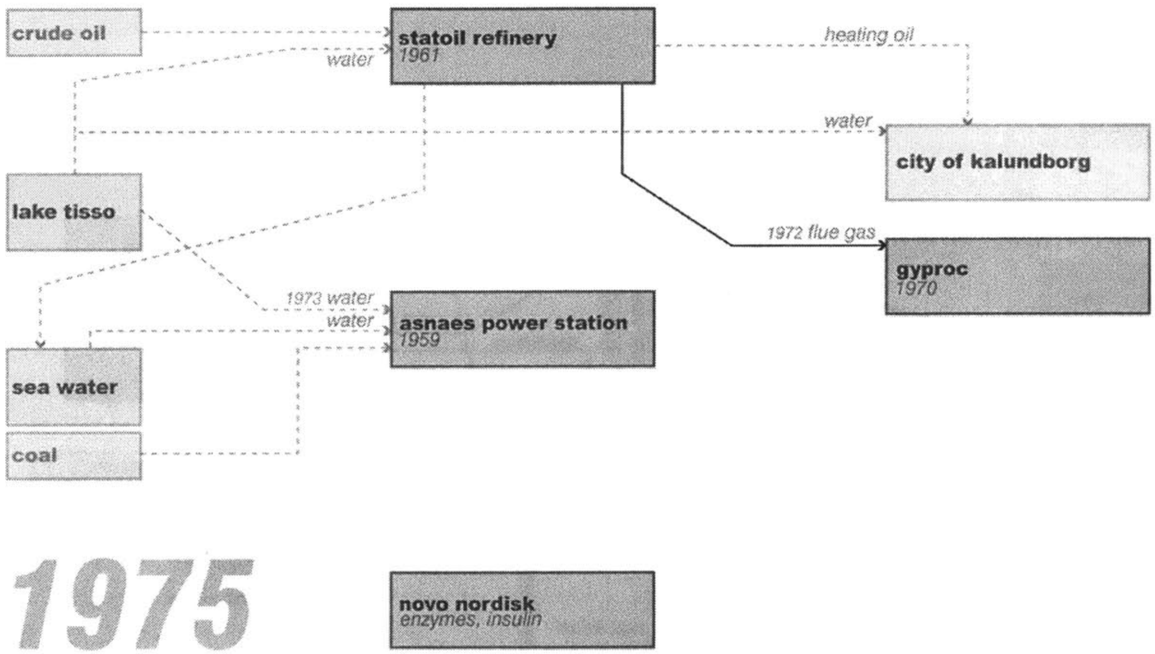


Figure 14: Kalundborg's Network of exchanges, 1975. Source: Adapted from Gertler (1995).

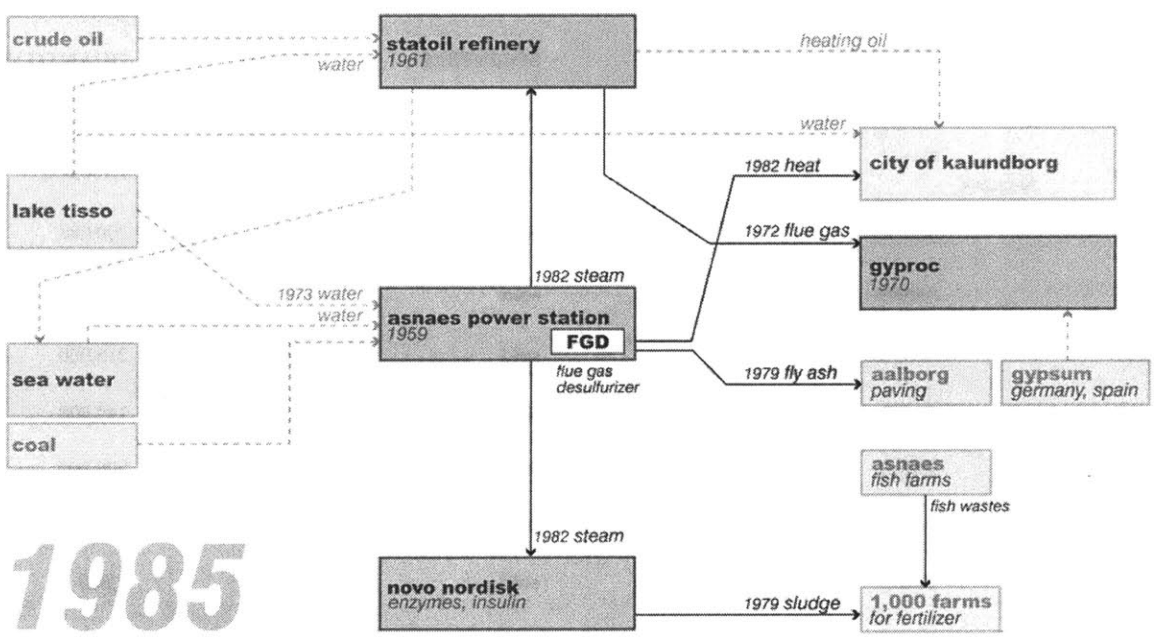


Figure 15: Kalundborg's network of exchanges, 1985. Source: Adapted from Gertler (1995).

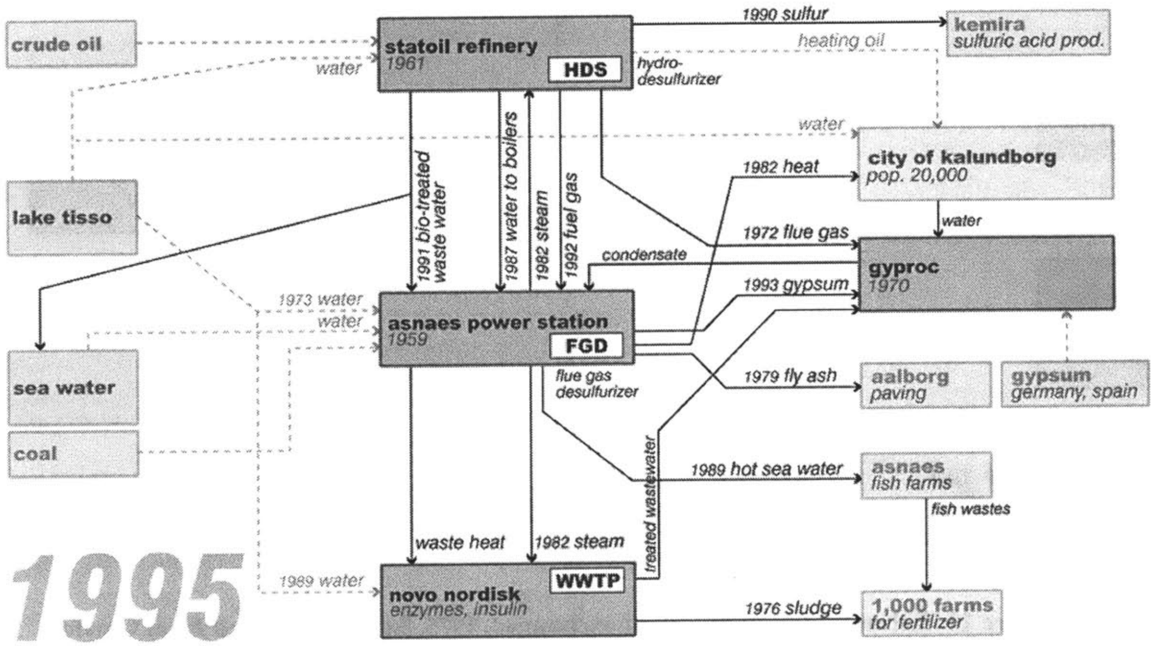


**Figure 16: Kalundborg's network of exchanges, 1995. Source: Adapted from Gertler (1995).**

| MATERIAL | FROM | TO | SOLD/FREE | BEGAN | QUANTITY(T/YR) |
|---|---|---|---|---|---|
| Fuel gas | Statoil | Gyproc | sold | 1972 | 8,000 |
| Sludge | Novo Nordisk | 1,000 Farmers | free | 1976 | 1,100,000 |
| Fly ash | Asnaes | Aalborg Portland | sold | 1979 | 200,000 |
| Steam | Asnaes | Kalundborg City | sold | 1981 | 225,000 |
| Steam | Asnaes | Novo Nordisk | sold | 1982 | 215,000 |
| Steam | Asnaes | Statoil | sold | 1982 | 140,000 |
| Water | Statoil | Asnaes | sold | 1987 | 700,000 |
| Hot sea water | Asnaes | Fish Farms | free | 1989 | ? |
| Sulfur (liquid) | Statoil | Kemira | sold | 1990 | 2,800 |
| Water, treated | Statoil | Asnaes | free | 1991 | 200,000 |
| Fuel Gas | Statoil | Asnaes | sold | 1992 | 60,000 |
| Gypsum | Asnaes | Gyproc | sold | 1993 | 85,000 |
| | | | | total: | 2.9 million tons |

**Figure 17: Source: Lowe (2001)**

## ***Environmental Aspects of the Symbiosis***

| | |
|---|---|
| **Reduction in Consumption of Resources** | |
| oil | 45,000 tons/year |
| coal | 15,000 tons/year |
| water | 600,000 m3/year |
| **Reduction in Waste Emissions** | |
| carbon dioxide | 175,000 tons/year |
| sulfur dioxide | 10,200 tons/year |
| **Valorization of 'wastes'** | |
| sulfur | 4,500 tons/year |
| calcium sulfate (gypsum) | 90,000 tons/year |
| fly ash (for cement, etc) | 130,000 tons/year |

**Figure 18: Source: Erkman (1998)**


**Figure 19: The spatial network of exchanges at Kalundborg. Source: Author, Google Maps.**

## *Case Study Two: The President's Council for Sustainable Development (PCSD): Industrial Symbiosis in the United States*

The United States has seen a variety of proposed eco-industrial parks inspired by Kalundborg promoted by the President's Council for Sustainable Development. President Bill Clinton established the PCSD in 1993 to "advise him on sustainable development and develop bold, new approaches to achieve our economic, environmental, and equity goals."[72] During the PCSD's run from 1993 to 1999 their major contribution to the establishment of industrial symbiosis in the US took the form of a major workshop held in October 1996 in which constituent firms from potential symbiosis networks all around the country convened in Cape Charles, Virginia. On paper, the PCSD's initiatives sounded impressive. President Clinton then remarked, "When I first appointed the Council almost three years ago, some of them knew each other only as adversaries. But with this report, they have shown us the power of partnership. They have demonstrated that when business, environmentalists, and government work together in good faith we can pursue simultaneously the goals of economic prosperity, social equity, and environmental quality."[73] The PCSD workshop saw 15 different eco-industrial park options from various sites around the country work together to identify strategies for expanding their visions of industrial symbiosis beyond the planning stages – necessary organizational structures, business attraction/retention schemes, performance standards, and finance. Ultimately, very few of the planned eco-industrial parks ever took root in the United States for a host of reasons. First, and somewhat obvious by now, the change in administrations from Bill Clinton to George W. Bush in 2000 redirected attention and funding away from anything 'sustainable development' oriented at the Federal level, thus, there is no longer a President's Council for Sustainable Development. However, and more importantly, the approach of the PCSD in establishing industrial symbiotic networks in the US was heavily focused on physical planning of EIP's, later discovered as a flawed methodology.[74] Big name architects like Bill McDonough were brought in to plan eco-industrial parks from scratch with relatively little knowledge of the entire foundation of communication, infrastructure, and regulations their success was predicated on. (McDonough was specifically commissioned to plan an EIP for Cape Charles, Virginia, where the PCSD Workshop was held.) Lastly, the firms slated for exchange were sometimes questionable in their sustainability and adaptive capacity. One such planned symbiosis network was slated for development in the Fairfield industrial zone in Baltimore, Maryland.

72 the PCSD website can still be accessed here: http://clinton4.nara.gov/PCSD/Overview/index.html Accessed 02 April 2007.

73 See this site for a complete summary of the Eco-Industrial Park proceedings: http://clinton2.nara.gov/PCSD/Publications/Eco_Workshop.html Accessed 02 April 2007.

74 Ironically, I originally approached my thesis from the vantage point of physical planning as well – Only to find it is part/whole of a host of tools needed for its widespread success discussed later in this thesis.

> "The clusters of industries at the Fairfield site are predominately related to petroleum and organic chemicals. The Fairfield 'carbon' economy includes oil company marketing sites, asphalt manufacturing and distribution, and divisions of multinational chemical companies making cleaning solutions, herbicides, and plating solutions. Companies at the Fairfield site include BP, Texaco, Mobil, Conoco, Shell, Sun Oil, Rone-Polenc, FMC, Vista Chemical, Clean America Corporation, Seaford Asphalt, and Colonial Pipeline."[75]

One can certainly see a major dilemma facing industrial ecology/symbiosis upon a quick glance at the types of industries listed above. Does industrial symbiosis just 'green' and promulgate the continued use of otherwise toxic, unsustainable industries? Without answering the question, one of the major reasons an industrial symbiosis network like that above would have difficulty is because of the similarity of industries and the relative lack of built-in resilience over time should those industries change. While some have managed to hang on and make some progress, most PCSD projects have failed due to the reasons listed above.

### *Value added by Planner*

Planners attempted to literally duplicate symbiotic exchange networks like Kalundborg from a top-down approach in the PCSD examples, failing to recognize that Kalundborg's success is based on its bottom-up, self-organizing nature. This is a major reason for the failure of most of the PCSD industrial symbiosis projects. Planners have learned from these failures, however, and have now shifted to facilitating and uncovering exchange networks from the bottom-up as well as top-down, as displayed by the next example in New Bedford, MA.

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[75] Abe, Joseph Michael, P.E. Dempsey, D. Allen. Business Ecology: Giving Your Organization the Natural Edge. Elsevier, 1998. pg. 148. This book also contains other detailed descriptions of some of the PCSD proposed eco-industrial parks.

## Case Study Three: New Bedford, MA

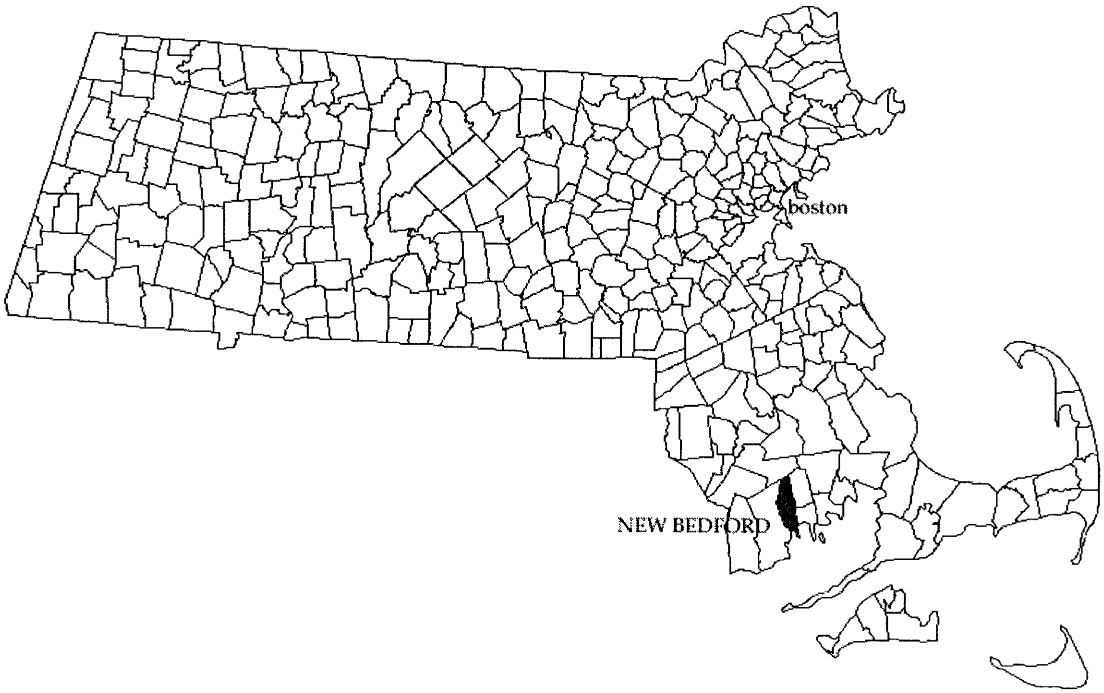



**Figure 20: New Bedford is about 60 miles south of Boston.**[76]

In contrast to the self-imposed, planned eco-industrial park approach by the PCSD initiatives, other industrial symbiotic networks have arisen in a bottom-up fashion quite similar to that at Kalundborg. One such example is the resource exchange occurring at New Bedford/Dartmouth Massachusetts.

External pressures have always been important to the formation of industrial symbiotic networks. New Bedford, along with Fall River, has an illustrious past as center of the fishing industry in southeastern Massachusetts. The transition away from a manufacturing economy to one of information and technology has been a difficult one. In 2004, 60 percent of information and technology firms chose to locate in greater Boston as compared to just 6 percent in "gateway" cities such as New Bedford, leaving the total number of private-sector jobs at their 1960s levels.[77] The coupling of this economic situation (among others) with the fact that the quantity of commercial and industrial solid waste generated by these two communities was above the permitted daily limit of the local landfill helped encourage the formation of the Sustainable Greater New Bedford (SGNB) committee in late 1999. "SGNB invited regional experts and businesses to describe alternatives for material use and reuse, water and energy consumption, waste reduction and recycling...[and sought to] survey companies regarding waste and material flows with the idea of developing a Southeastern

76 Image by author, adapted from http://en.wikipedia.org/wiki/Image:New_Bedford_ma_highlight.png

77 Schweitzer, Sara. "11 Cities Seen at Risk of Slipping Further." Boston Globe. February 26, 2007. Accessed 27 February 2007 from http://www.boston.com/news/local/articles/2007/02/26/11_cities_seen_at_risk_of_slipping_further/?rss_id=Boston+Globe+--+Front+Page

Massachusetts' virtual eco-industrial park."[78] (Virtual here is referring to exchanges occurring over a distance, not directly linked.) SGNB's leadership in connecting issues such as economy and environment were important assets from the onset of this exchange network.

After securing money from the Chelsea Center for Recycling and Economic Development's grant program, SGNB hired Marsha Gorden of The Resource Technologies Group of Cambridge, MA to analyze the material and waste streams within New Bedford and identify potential exchanges. The following is derived from speaking with Gorden.

There were three major waste streams identified: organic wastes from fish and food processing, institutions and restaurants, rubber processing wastes from golf ball and gasket companies, and wood wastes derived from building materials and pallets.[79] Incorporating waste exchange methods to the fish processing sector proved the most successful sector. No organic wastes were allowed in the local landfill (which was already over its limit in daily intake), and the processed fish gurry overburdened the wastewater treatment plant comprising 40-50% of the total wastewater flow. (Statistically, there are about 40 fish processing plants in New Bedford, contributing about 70 million pounds/yr of suspended solids to the WWTP). Gorden met with Advanced Marine Technologies, the firm ultimately responsible for capitalizing on such large fish processing waste streams by converting them into a highly successful fertilizer called OrganicGem and other nutraceuticals.[80] As it stands today, about 30% of the entire fish waste stream is recycled for the creation of this fertilizer.

The second sector of rubber scraps proved to be a more difficult waste stream to deal with. Titleist, the golf ball manufacturer, and Precix (formerly Acushnet) were the primary suppliers of rubber scrap, in which a larger geographical region needed to be analyzed for potential users. The scrap rubber is now being used as a new asphalt and roadway paving material by a Providence, RI company for use throughout Rhode Island. (Massachusetts has laws ruling against the incorporation of such materials in its paving, thus preventing in-state, local re-use.) The wood waste sector has made little headway thus far, although there is a planned biofuels plant within New Bedford's industrial park which could potentially facilitate exchanges in that area. A summary of the exchanges and important players within the symbiosis at New Bedford:[81]

- The Greater New Bedford landfill is over capacity and doesn't allow organic waste disposal

78 Gorden, Marsha. "Sustainable New Bedford Phase 1." Chelsea Center for Recycling and Economic Development. November 2002. Retrieved 22 January 2007 from http://www.chelseacenter.org/pdfs/RBED_NewBedford.pdf
79 Gorden, Marsha. Personal Communication. January 2007.
80 The OrganicGem product website can be found here: http://www.organicgem.org/ Accessed 02 March 2007.
81 As compiled by Marsha Gorden's company, The Resource Technologies Group: http://www.sustainableresources.com/projects_newbedford.html Accessed 22 January 2007.

- The New Bedford Wastewater treatment plant was overwhelmed with fish processing waste water, which contributed to high nitrate concentrations when discharged into Buzzard's Bay
- Fish Processing Plants provide waste stream
- AMT reprocesses these into organic fertilizers and nutraceuticals
- Titleist and Precix provide rubber scraps
- A paving company in Providence, RI creates rubber-modified asphalt and paving from the scraps
- UMASS Dartmouth is a test-site for the OrganicGem fertilizer and rubber-modified asphalt.
- The New Bedford Business park (home of the Titleist production facilities) has waste wood scraps potentially re-usable by a biomass cogeneration project at UMASS Dartmouth

The industrial symbiosis at New Bedford is a type 5 (exchanges occurring across geographic distance) within Chertow's classification system -- most exchanges utilize highway/transport conduits to facilitate exchange over geographic distance, also known as 'virtual symbiosis'. Still, it operates with primarily local organizations and businesses with a regional output scope. Its successes thus far can be attributed to its external constraints (landfill and wastewater treatment plant limits), educated and inspired leadership in the form of the SGNB committee, communication between firms, technical analysis (as performed by Marsha Gorden/TRTG), regulations (no organic materials allowed at landfill), and its continued support and monitoring by TRTG and the City Council looking for more opportunities for exchange.

### *Value added by Planner*

The industrial symbiosis at New Bedford clarifies that the role of industrial symbiosis facilitator need not always be a trained "planner", but rather someone versed in the technical knowledge needed by industries to better understand potential exchange linkages. As such, planners versed in this technical knowledge can greatly add to the industrial symbiosis facilitation process, while bringing long-term thinking to the table as well. The next example of Devens, MA displays these characteristics.

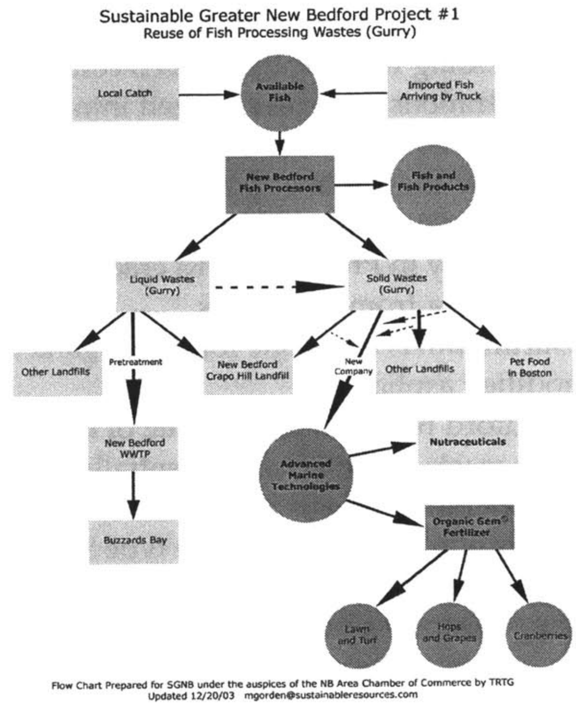



**Figure 21: The exchanges of fish processing wastes at New Bedford.**

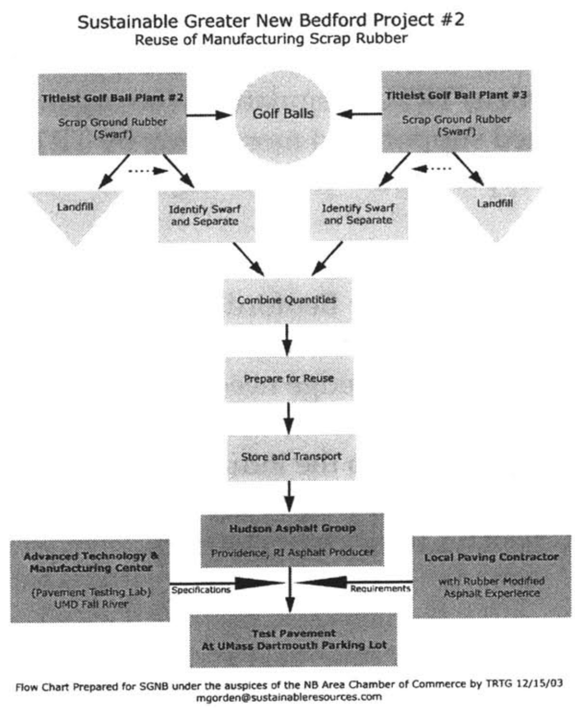



**Figure 22: The exchanges of rubber scraps at New Bedford.**


**Figure 23: The spatial network of exchanges at New Bedford. Source: Author, Google Maps.**

## Case Study Four: Devens, MA

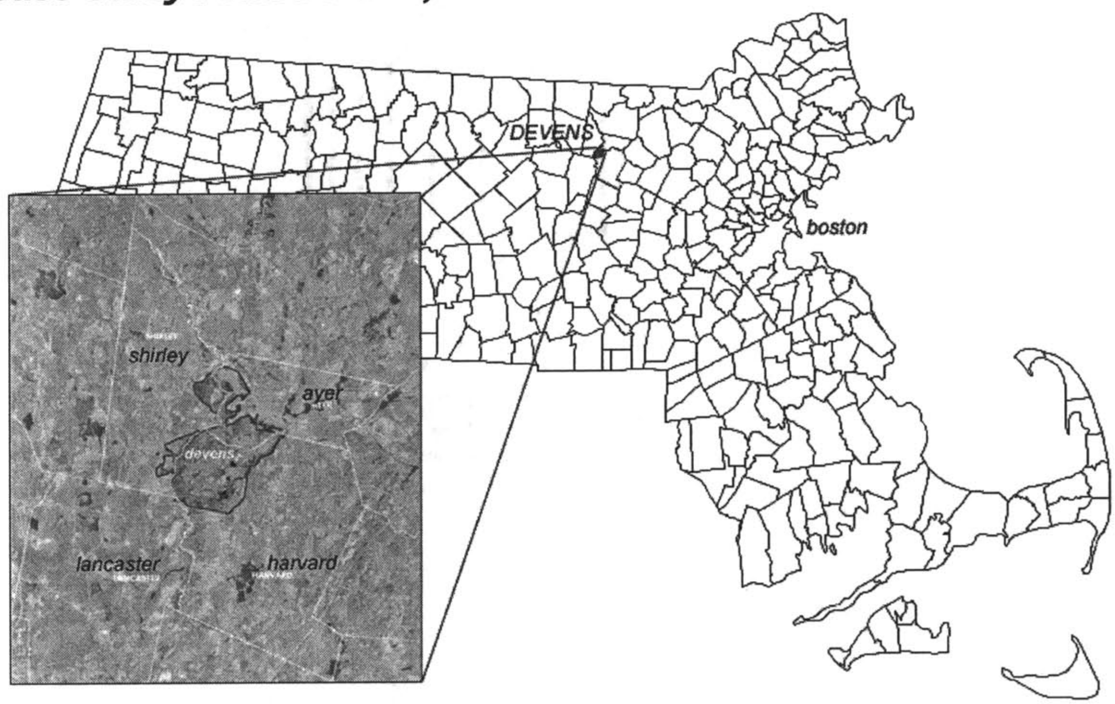



**Figure 24: Devens is roughly 40 miles west of Boston.**[82]

Industrial ecology and symbiosis are beginning to be combined with urban/regional planning and projected change over time. In contrast to the previous case studies of Kalundborg and New Bedford where symbiotic networks were created within an existing urban fabrics, Devens is only beginning its transition from former military base into full-blown town. It is a particularly interesting case study because it enables the study of:

- How attempts have been made to grow an industrial symbiotic network and town simultaneously
- How to deal with the future prospects of large-scale patterns of industrial development in the United States coupled with the concepts of industrial ecology.

Devens is a former military base closed in 1996 after operating for 79 years. It is part of a much larger base-closing scheme of the U.S. government in which 97 major bases around the country were closed between 1988 and 1995.[83] The 3,040 acre Fort Devens complex was purchased from the federal government by the state for $17.9 million to be developed into a mixed use community comprised of housing, commercial, and industry.[84] It is critically located on major infrastructural conduits such as inter-modal rail and accessible highways roughly 40 miles northwest of Boston, showcasing larger trends of industrial

82 Image by author, adapted from http://en.wikipedia.org/wiki/Image:Harvard_ma_highlight.png
83 U.S. Department of Defense official website: http://www.defeselink.mil/brac and also Berger, Alan. Drosscape: Wasting Land in Urban America. New York: Princeton Architectural Press, 2006. pg 66.
84 Ibid.

agglomeration development at similar distances away from major urban centers.[85] (Much more about this will be discussed in the upcoming chapter.) Its industrial land use component has seen a build out around 4.5-5 million square feet over the past 10 years and is permitted to grow to 8 million square feet.[86]

In should be noted that actual symbiotic changes are only in the planning phase and are not yet operational. Still, the concepts of industrial ecology/symbiosis have been built into the Devens overall reuse master plan from the outset, stating growth should "demonstrate the interdependence of economic development and environmental protection and the symbiosis of public and private uses."[87] Much of this is due to the knowledge and expertise of lead planner Peter Lowitt, who has been involved with industrial ecology/symbiosis for over 10 years and served as a planner in the development of one of the PCSD projects in Londonderry, NH. Much of the information about this study is derived from personal communication with Lowitt.

Initial studies of how industrial symbiosis could occur within Devens are underway; the major material flows have already been identified (in order of quantity) as corrugated cardboard, paper, plastic, metal scrap, wood palettes, and machine oil – all representative of the light industry base prominent in what remains of American industry. The reuse plan has identified all of the major principles necessary for facilitating symbiosis networks: material/water/energy flows, proximity between firms, strong inter-firm communication, infrastructure, and anchor tenants. While mechanisms for each are in place, the most critical missing element thus far seems to be the lack of "anchor tenants". The potential 'anchor tenant' could be realized once development puts a strain on neighboring waste water treatment plant limits. "Currently, MassDevelopment (the development body behind Devens) has agreements with Ayer, Shirley, and MCI Shirley regarding water supply. It may benefit the towns and MassDevelopment to continue to build on these arrangements."[88] There are currently two industrial zones within Devens, the first is a 795 acre portion devoted to 'innovation technologies' – it is populated with firms such as American Semiconductor, Xinetics (motion-sensing), Johnson Matthey, and Bristol, Myers, and Squibb.[89] The other, 300 acre industrial zone caters to rail and trade-related industry, attracting businesses that require freight (there is an inter-modal rail link) and truck access. As such, Gillette bases it's a large portion of its New England operations here with an $18 million warehouse/packing/distribution facility, and $50 million manufacturing plant.[90] Other major corporations such as Kraft foods have facilities here as well, utilizing the regional supply-chain capacities

[85] Berger, Alan. Drosscape: Wasting Land in Urban America. New York: Princeton Architectural Press, 2006.
[86] Lowitt, Peter. Personal Communication. February 2007.
[87] Devens Disposition Executive Board. "2006 Devens Reuse Plan." September 1, 2006. pg. 2.
[88] Devens Disposition Executive Board. "2006 Devens Reuse Plan." September 1, 2006. pg. 61.
[89] Devens Disposition Executive Board. "2006 Devens Reuse Plan." September 1, 2006.
[90] Berger, Alan. Drosscape: Wasting Land in Urban America. New York: Princeton Architectural Press, 2006. pg. 67.

currently demanded by contemporary industry and enabled by the infrastructural access.

The Devens reuse plan also incorporates a sizable housing component: 1,800 units are to be constructed over the next 20 years. Contrasting to the urban fabric-embedded forms of symbiosis at Kalundborg and New Bedford, there will be little symbiotic potential between industrial and non-industrial uses, solidified by statements like "ensure adequate buffers between commercial and existing and proposed residential uses."[91] This can be attributed to the current footprint of industrial land uses and the relative low density of residential development supported by abundantly available land hinged on cheap mobility.

While there are no major resource exchanges occurring at Devens yet, it provides a model of how industrial symbiosis can be approached from scratch, and at the massive current scale of regionally agglomerated industries in the United States. Whether or not industrial symbiosis can be "planned" at this scale of operations is still up for debate, however, the next case study certainly suggests it can be.

### *Value added by Planner*

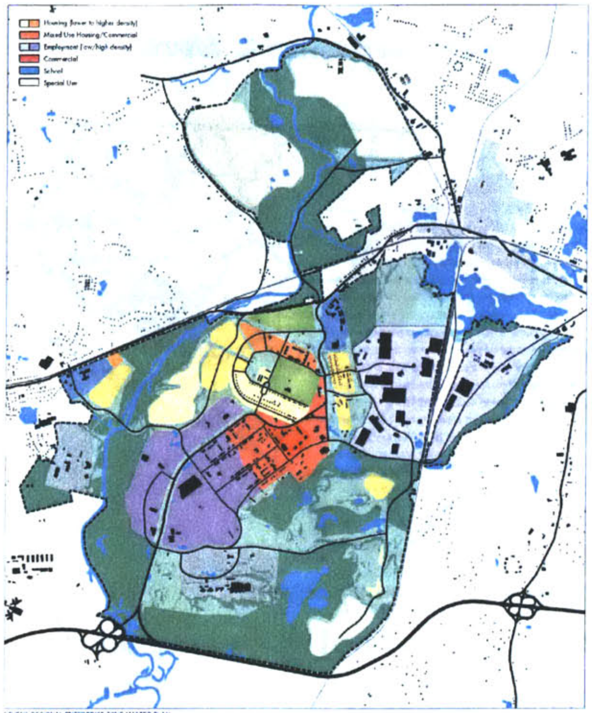
The ability to understand change over time, accommodate the needs of various constituents, and comprehend the tools of industrial symbiosis are all showcased by the planning at Devens. Most importantly, it highlights the potency of planners included at the beginning of the industrial symbiosis development. The next case study couples this inclusion of planners from the start with advanced technology tools that facilitate symbiosis.

[91] Ibid. pg. 49.


Figure 25: Existing Conditions at Devens. Source: Google Maps


DEVENS CURRENT LAND USE

**Figure 26: Devens Existing Land Use. Source: Devens 2006 Reuse Plan.**



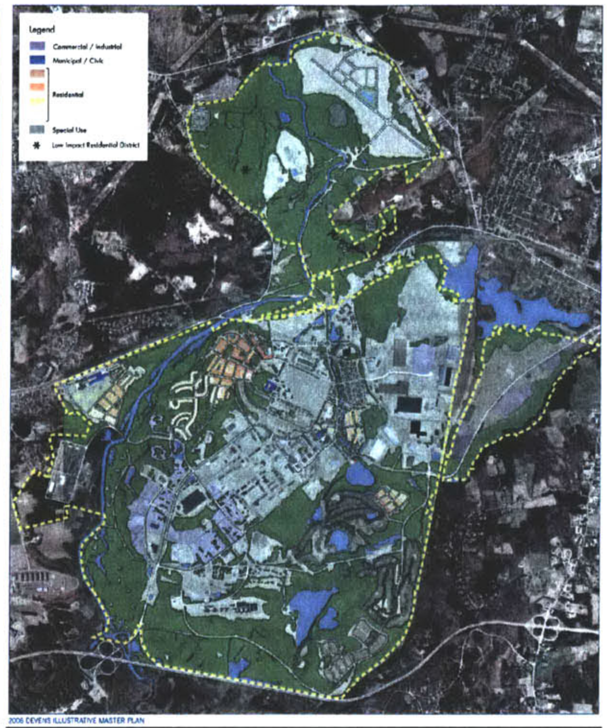




**Figure 28: Projected Land Use at Devens. Source: Devens Reuse Plan.**

**Figure 27: Projected Master Plan at Devens. Source: Devens Reuse Plan.**

## *Case Study Five: Triangle J Council of Governments, North Carolina*

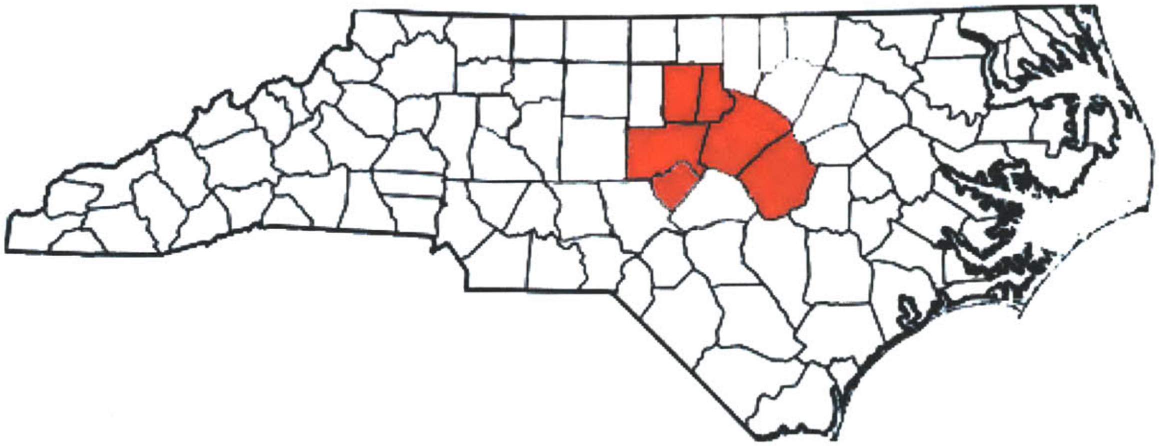


**Figure 29: The study area of a six-county region[92]**

The "research triangle" of North Carolina is defined by the geographic location of Duke, UNC-Chapel Hill, and North Carolina State Universities. It encompasses six counties, Wake, Durham, Orange, Chatham, Johnston, and Lee, which collectively have a population of over 1 million people.

Inspired by the industrial symbiosis at Kalundborg, in the late 1990's the Triangle J Council of Governments (one of 17 regional government entities in North Carolina) sought out to collect data on local resource use to encourage exchange. The US Environmental Protection Agency (EPA), which happens to have a major office located in the region, realized the "lack of easily available local information on potential [industry] partnerships for resource reuse. It therefore funded a two-year project based in North Carolina called the Industrial Ecosystem Development Project."[93]

This is an extremely important case study because it increases the scale of material and resource flow analysis to the urban and regional levels, laying the foundation for current practices in measuring urban metabolism. It also incorporated GIS databasing of materials flow and potential connections for the first time, and emphasized the importance of funding mechanisms and local champions of the industrial ecology cause. Lastly it serves as a model for how to apply symbiosis and systems thinking at the massive regional scale of United States industry – far beyond the limitations of exchange networks predicated on physical proximity.

As specified by its title, the research triangle is comprised of a host of advanced industries. The largest are pharmaceutical, computer, telecommunications, medical and educational institutions, biotechnology, and state/federal agencies represented by companies such as BASF, Bayer, GE, Cisco,

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[92] Image by author, adapted from http://en.wikipedia.org/wiki/Image:Researchtrianglearea.png

[93] Kincaid, Judy and Michael Overcash. "Industrial Ecosystem Development at the Metropolitan Level." Journal of Industrial Ecology. 2001: 5(1); 117-126.

Merck, Wyeth, IBM, Nortel and Novo Nordisk/Novozymes (also located in Kalundborg). They are served by the major infrastructural conduits of three interstates, two interstate spurs, and six secondary highways.[94]

The two-year study's main objectives were:

- Develop effective methods of acquiring information useful identifying potential local partnerships for the reuse of materials, water, and energy.
- Produce predictive data associated generic industry types with specific reusable by-products
- Evaluate the usefulness of establishing a local infrastructure for the identification and promotion of by-product reuse opportunities[95]

Methodologically, the group designed a survey to be distributed to each of the 343 industries located in the six county region, of which 182 complied by submitting information and agreeing to further communication. Of these 182 industries, the data showed potential by-product exchanges between 48% (approx. 87) of them.[96] Resource types were categorized by level of effort and time needed to establish symbiotic exchanges.
Estimates were then made on the level on economic and environmental impact the exchanges would result in, ultimately highlighting the benefits of symbiosis. In total, the data collection project emphasized the important role of "symbiosis facilitator", responsible for the following:

- Convincing people to provide and share information
- Gathering, managing, and displaying information
- Analyzing information and identifying potential partnerships
- Convening meetings of potential partners
- Encouraging and assisting partnerships that needed additional help[97]

The Triangle J Council of Governments regional symbiosis study set things in motion for understanding industrial operations as systems in an environment normally used to concealing information. As mentioned above, the importance of symbiosis facilitator or "local champion" is essential. Lastly, it provided a loose example of how costly such a study is, suggesting that a "project for an area the size and type...could probably be maintained on an annual budget as small as $80,000 (annually), given the ability of graduate student assistance."[98]

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[94] Kincaid, Judy and Michael Overcash. "Industrial Ecosystem Development at the Metropolitan Level." Journal of Industrial Ecology. 2001: 5(1); 117-126.
[95] Ibid.
[96] Ibid.
[97] Kincaid, Judy and Michael Overcash. "Industrial Ecosystem Development at the Metropolitan Level." Journal of Industrial Ecology. 2001: 5(1); 117-126.
[98] Ibid.

### *Value added by Planner*

In this case study, the technological service provided by GIS in resource matching and mapping exchange possibilities was the greatest facilitator of industrial symbiosis. Planners are well equipped with this knowledge and can provide geospatial resource mapping and matching at multiple scales, from the individual firm to the scale of an entire city, and beyond. The next case study displays how potent symbiosis can be if implemented at the city, regional, and national scales.

**Table 2** By-products and inputs for which reuse partnerships involving project participants were deemed probable in the short term

| | | |
|---|---|---|
| Acetone | Methanol | Sodium hydroxide |
| Carbon | Packaging materials | Wood ash |
| Dessicant | Plastic bags | Wood chips |
| Hydrochloric acid | Sawdust | Wood fluff |

**Figure 30: Potential by-products for exchange the six county region.**

**Table 3** By-products and inputs for which reuse partnerships involving project participants were deemed possible with further effort

| | | | |
|---|---|---|---|
| Absorbents | Electricity | Furniture fluff | Steam |
| Blasting media | Ethanol | Glass vials | Steel |
| Coal ash | Fiberglass | Ink | Sulfuric acid |
| Conveyor belts | Floppy disks | Paint | Unheated water |
| Copper | Food waste | Plastic | Wire |
| Drums | Foundry sand | Rubber blankets | Wood |

**Table 4** By-products and inputs for which reuse partnerships involving project participants were deemed unlikely

| | | | |
|---|---|---|---|
| Chromic acid | Kaolin clay | Plastic IC tubes | Solvents |
| Concrete paste | Nitric acid | Plastic sheeting | Tobacco dust |
| Fabric | Phosphoric acid | Soap | Heated water |
| Hydrogen peroxide | | | |

**Figure 31: By-products requiring more effort for exchange.**

**Table 5** Annual economic and environmental impact of selected potential partnerships*

| | *Acetone* | *Carbon* | *Desiccant* | *HCl* | *Methanol* | *Packing material* | *Plastic bags* | *Sawdust* | *Wood chips* |
|---|---|---|---|---|---|---|---|---|---|
| Savings to seller | $10,920 | $3,750 | $6 | ? | $100,800 | $1,459 | $620 | $0 | $1,760 |
| Savings to buyer | $18,000 | $0 | $1,500 | $1,056 | $70,800 | $4,562 | $5,443 | $2,600 | $0 |
| Total savings | $28,920 | $3,750 | $1,506 | ? | $171,600 | $6,021 | $6,063 | $2,600 | $1,760 |
| Miles savings to seller | 5,100 | 312 | 22 | 0 | 0 | 822 | 66 | 0 | 416 |
| Miles savings to buyer | −205 | 0 | 786 | −963 | −140 | 4,052 | 2,862 | 960 | 0 |
| Total miles savings | 4,895 | 312 | 790 | −936 | −140 | 4,874 | 2,928 | 960 | 416 |
| Amount exchanged | 5,005 gal | 150 T | 0.2 T | 1,320 gal | 240K gal | 45 T | 15 T | 2,640 gal | 70 T |

*T = 1 short ton ≈ 0.907 metric tons ≈ 0.907 megagrams (Mg); gal = 1 gallon ≈ 3.79 liters.

**Figure 32: Quantitative analysis of economic and environmental benefits provided by exchange.**

## Case Study Six: UK's National Industrial Symbiosis Programme (NISP)

It has become clear throughout all of these case studies just how critical open communication between firms is to getting symbiotic exchanges off the ground. NISP, the United Kingdom's national-scale government-initiated organizational body responsible for facilitating communication at various scales, shares the same acronym with the United States' National Industrial Security Program, a contrasting "partnership between the federal government and private industry to safeguard classified information."[99] One more mental mountain to climb for the establishment of industrial symbiosis in the US context.

The National Industrial Symbiosis Programme is currently the only nationally-scaled operation of its type in the world. It is a business-driven organization responsible for generating economic, environmental, and social benefits for industries through facilitating symbiotic exchanges across the United Kingdom. Established in July 2005, its founders were inspired by the United States Council for Sustainable Development's recent initiatives of facilitating by-product exchange between companies along the Gulf Coast, garnered the interest within the House of Commons, secured financing, and implemented the strategy at unprecedented scale. The lessons of "symbiosis champion" taught by examples like the Triangle J case study are built into the ideology of NISP, as it serves as the logistical go-between for industries capable of symbiotic exchange.

NISP operates with 12 regionally based offices across England, Wales, Scotland, and now Ireland serving as the intermediate between local needs and national goals. "By having a regionally delivered but linked national programme, business problems identified in one region can often have solutions developed in a second and benefits delivered in a third."[100] It is funded through money generated by increased landfill taxes (the UK certainly has less room than the US) and other outlets by region. It also has well-linked partnerships with the UK's Environment Agency (US version: EPA), the Resource Efficiency Knowledge Transfer Network and the Local Government Association.[101] Since August 2005, it has:[102]

- diverted over 1.1 million tonnes of waste from landfill
- eliminated 423,000 tonnes of hazardous waste
- reduced CO2 emissions by over 1.3 million tonnes
- saved 1.9 million tonnes of virgin materials
- reduced industrial water usage by over 1.1 million tonnes
- created 356 new jobs and safeguarded another 301
- been responsible for 15 new business start ups
- made cost savings to UK industry totaling over £47 million

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[99] http://www.archives.gov/isoo/oversight-groups/nisp/ Accessed 15 April 2007.
[100] http://www.nisp.org.uk/about_us_approach.aspx Accessed 02 April 2007.
[101] http://www.nisp.org.uk/about_us_funding.aspx Accessed 02 April 2007.
[102] http://www.nisp.org.uk/about_us_approach.aspx Accessed 02 April 2007.

- generated £39 million in additional sales for its members
- seen private investment of £34 million in reprocessing and recycling plant
- been instrumental in the development of numerous brownfield sites

Typical case studies of NISP's work in action involve:

- the reduction of vehicular miles traveled per year by finding advanced technologies to re-use harmful by-products instead of sending them to landfills
- redeveloping brownfield sites to grow biomass for renewable energy utilizing reprocessed compost
- the recycling of construction materials typically sent to landfills.

NISP raises the bar of what industrial symbiosis is capable of. It showcases possibilities only attainable when multiple levels of industry and government understand the consumption reduction and economic benefit capacities of resource exchange. However difficult it may seem to apply the NISP model to the United States, NISP's founders were actually inspired by symbiotic exchange networks they observed on the Gulf Coast.[103] Smaller scale symbiotic networks do exist in the U.S., yet, could gain immensely from NISP's well-developed regulatory and communication structure and its unprecedented visibility and scope.

### *Value added by Planner*

The UK's National Industrial Symbiosis Programme operates at such a scale that it is necessary for it to include planners to facilitate industrial symbiosis. However, most important at this point in time in the US context is the need for planners to advocate such a regulatory structure to be created within America, adapting it to the complexities of the current scale of industrial operation that this nation contains. The planners ability to do so will be facilitated by future trends in energy and their consequences to the scale and means of industrial operations in the United States. These concepts are the core of the next chapter.

103 http://www.nisp.org.uk/p_laybourn.aspx NISP director Peter Laybourn was once a Shell employee. Accessed 20 March 2007.

# Chapter Four

*"Humans, individually or in groups, can anticipate and prepare for the future to a much greater degree than ecological systems. This creates complicated dynamics based upon access to information, ability to organize, and power. In contrast, the organization of ecological systems is a product of the mutual reinforcement of many interacting structures and processes that have emerged over long periods of time. Consequently, the arrangement and behavior of natural systems is based upon what has happened in the past, rather than looking in anticipation toward the future...understanding the role of people in ecological systems requires not only understanding how people have acted in the past, but also how they think about the future."*
*- Gary Patterson*

*"Time makes more converts than reason."*
*– Thomas Paine*

*"It's all good."*
*- Common American Slang*

## Attributes for Success

It should be noted that industrial ecologists have high hopes for the future of industrial symbiosis and its abilities to mitigate human impacts on the natural world. The ultimate vision of reformatting contemporary industry into a model resembling a closed-loop natural ecosystem is best described by Raymond Côté of Dalhousie University:

- Industrial parks should be designed in a manner which maintains as many of the ecological functions of the landscape as possible.
- Industrial parks should strive to lower the overall level of material use per unit of production while maintaining standards of quality and safety.
- Industrial parks should reduce the use of toxic and hazardous materials when alternatives are available.
- Industrial parks should favor the use of renewable over non-renewable resources in building materials, energy use, products and services.
- Industrial parks should adopt waste prevention as an underlying design criterion, ensuring that park layout, infrastructure, buildings and industrial processes are operated accordingly.
- Industrial parks should strive for diversity of industries, businesses, materials, products, and services compatible with the capacity of natural systems to absorb their impacts.
- Industrial parks should create the necessary physical, administrative and financial infrastructure to facilitate the cycling of waste materials first into processes which generated them and second, into other processes.
- Industrial parks should encourage products and services which have no undue environmental impact and are safe in their intended use, that are

> efficient in their consumption of energy and natural resources, and that can be recycled, reused or disposed of safely.[104]

To achieve all (or any) of these, necessary characteristics are needed for the successful implementation of industrial symbiotic networks. While there have been case studies to test and verify these claims, most desired attributes expressed by major thinkers in the field are still prescriptive wish-lists of traits often existing singularly, yet difficult to create in total. Below is a compilation of these traits necessary for the successful implementation and operation of industrial symbiosis.

Coupling the attributes mentioned above, one can see five distinct categories emerge:

1. Technical Information
2. Communication
3. Regulations
4. Industry Types
5. The Proximity Issue

**Technical Information**

Extensive databases and metrics capable of displaying the entire picture of material and energy flows must be available if industries are to successfully exchange resources and by-products. Major progress is occurring in this area beyond what was envisioned at the time these early proponents of industrial symbiosis were writing. Entire cities and nations are beginning to track and measure material and resource flows, accumulating data and understanding the complexity of industrial metabolism.

One example of this is taking place in Portugal. Established by the joint MIT-Portugal program, the IST Technical University of Lisbon is collecting and databasing the material flows for both the country of Portugal and its capital city.

Increased understanding of resource and energy flows at this scale provides tremendous opportunities for the expansion of symbiotic exchanges. What needs to happen now? City planners and urban designers need to work with those collecting this data to understand how it could translate into spatial configurations that facilitate such exchange at the urban and regional levels. This will be discussed later in this chapter.

[104] Côté, R. and J. Hall. "Industrial Parks as Ecosystems." Journal of Cleaner Production. 1995: 3 (1-2); 41-46.

| **Gertler[105] (1995)** | **Côté[106] (1997)** | **Lowe[107] (1997)** | **Chertow[108] (2000)** | **Schlarb[109] (2001)** | **NISP[110] (2005)** |
|---|---|---|---|---|---|
| **Analysis of Kalundborg** | **Supporting Pillars of Industrial Ecosystems** | **Creating By-Product Resource Exchanges** | **Industrial Symbiosis: Literature and Taxonomy** | **Eco-Industrial Development** | ***derived from actions, not text*** |
| Industries Must Match | Technical Information | Clear Vision | Input-Output Matching | Supply of by-products must meet demand (and vice versa) | Institutional Frameworks facilitate exchanges |
| Size of Industries must match | Economic Instruments | Screening of Companies | Stakeholder Process (communication and vision) | Physical Proximity to compatible firms | Physical Proximity is NOT necessary |
| Close Physical Distance | Regulations | Technical Information | Materials Budgeting | Regulations | |
| Close Mental Distance | | Flexibility in recruitment | Recruitment based on streams | Institutional Frameworks facilitate exchanges | |
| Regulations Create Financial Incentives | | Assurance of Future Support | | | |
| Negotiations at the local level are more effective | | | | | |

**Figure 33: Attributes needed for Successful Industrial Symbiosis.**

105 Gertler, Nicholas. Industrial Ecosystems: Developing Sustainable Industrial Structures. MIT Master's Thesis. 1995.
106 Côté, R and Theresa Smolenaars. "Supporting Pillars for Industrial Ecosystems." Journal of Cleaner Production. 1997: 5 (1-2); 67-74.
107 Lowe, Ernest A. "Creating By-Product Resource Exchanges; Strategies for Eco-Industrial Parks." Journal of Cleaner Production. 1997: 5(1/2); 57-65.
108 Chertow, Marian R. "Industrial Symbiosis: Taxonomy and Literature." Annual Review of Energy and Environment. 2000. 25: 313-37.
109 Schlarb, Mary. "Eco-Industrial Development: A Strategy for Building Sustainable Communities." Cornell University, WEI: Ithaca, NY. Retrieved 2 February 2007 from http://www.usc.edu/sppd/research/NCEID/Bahl-Presentation.ppt
110 National Industrial Symbiosis Programme (NISP). United Kingdom. http://www.nisp.org.uk/ accessed 02 March 2007.

### Communication

While open communication between industries is a necessity for successful industrial symbiosis, it can be categorized in two different forms. Older case studies of industrial symbiosis such as the direct, physical exchanges at Kalundborg suggest that bottom-up, stakeholder driven, local-level communication is most effective. Newer modes of symbiosis over larger geographical expanses have been successfully facilitated by national/regional institutional frameworks responsible for connecting the dots, as exemplified by the UK's NISP. Communication, in this case, refers to the internal switch from industries currently keeping resource and other operational information undisclosed to opening up and seeking out potential resource exchanges. Trends in larger communication technologies can catalyze this spillover in increased openness and knowledge. Both the local-level and institutional-level forms of communication will need to take advantage of current advances in technology, be it in the form of web-based knowledge transfer or opportunities provided by information accessible via cell-phone. What if firms developed public, on-line databases which track material uses, needs, and effluents? What if real-time information regarding sought-after exchanges was made available via cell-phone or website? What if firms already engaged in exchanges utilized the web and other media outlets to advertise and market their ecological and economic benefits? More on this later.

### Regulations

Symbiosis is always facilitated by some constricting parameter. Whether it was the firms of Kalundborg searching for ways to mitigate precious fresh-water use, or New Bedford's over-capacity landfill, some form of constraint usually instigated the exchanges. For industrial symbiosis to take hold, regulations on waste, emissions, and the use of dwindling resources will certainly need to increase. These regulations have the chance to get the economics right for exchange, and should also contain rules and incentives for the continuing exchange of resources and energy.

### Industry Types

These last two categories will be increasingly important as we transition away from fossil fuel dependency. As previously stated, industrial symbiosis performs best when there is a diversity of industry types engaged in exchange, thus resembling the essential diversity found among natural ecosystems. However, industry as it currently exists in the United States will see major changes in the near future. The current state of industry in the US and catalysts for these changes will be discussed later in this chapter.

### The Proximity Issue

Case studies such as Triangle J and NISP have displayed that it is possible for exchange to occur over distance (virtual industrial symbiosis). "Historically, it was considered that for industrial symbiosis to work effectively the companies involved must be linked by close geographic proximity. This is no longer the case; although low value/grade materials and heat are restricted by proximity constraints, higher value synergies have no such restrictions."[111] This will become a major focal point in this study due to the fact that exchange over distance is predicated on cheap mobility – which is projected to change in the near future. How industrial symbiosis and urbanism adapts to these trends in the United States context will serve as the centerpiece of this chapter.

## Constraints on Industrial Symbiosis

Along with attributes necessary for the success of industrial symbiosis, specific constraints have also been identified: (similar ideas have been grouped by the author)

**Resource Supply Balance**

- "stability of supply is considered the 'Achilles Heel' of eco-industrial parks"[112]
- "companies using each other's residual products as inputs face risk of losing a critical supply or market if a plant closes down or changes its product mix"[113]
- "uneven quality of by-product materials could cause damage to equipment or quality of products."[114]

**Existing Regulations**

- zoning by-laws impede possibilities
- current laws demanding disposal of by-products, wastes, effluent
- possible innovations in regulation to enable EIP development may not be allowed by regulatory agencies (laws, firewalls)[115]

**The "Usual Suspects"[116]**

- risk
- finance
- mobility of capital

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111 National Industrial Symbiosis Programme (NISP). United Kingdom. http://www.nisp.org.uk/ accessed 02 March 2007.

112 Côté, R and Theresa Smolenaars. "Supporting Pillars for Industrial Ecosystems." Journal of Cleaner Production. 1997: 5 (1-2); 67-74.

113 Lowe, Ernest A. "Creating By-Product Resource Exchanges; Strategies for Eco-Industrial Parks." Journal of Cleaner Production. 1997: 5(1/2); 57-65.

114 Ibid.

115 Ibid.

116 Chertow, Marian R. "Industrial Symbiosis: Taxonomy and Literature." Annual Review of Energy and Environment. 2000. 25: 313-37.

- higher payback options elsewhere

**The Big Issues**

- pollution prevention vs. industrial ecology[117]
- exchange of by-products could lock in continued reliance on toxic materials[118]
- industry in its current form is highly dependent on massive quantities of fossil fuel inputs, will need to re-think its entire mode of operations

This series of successful attributes and constraints led Dr. Marian Chertow to identify four potential approaches to the implementation of industrial symbiotic networks:[119]

- plug into and expand upon existing exchanges such as electricity co-generation
- plug into and expand upon existing organizational relationships
- utilize "anchor-tenant" model: power plants, electricity generation (urban waste collection?)

The last point made, albeit mentioned as "combine eco-industrial parks with new urbanism trends in residential development" and "governments could latch onto eco-industrial parks as another way to redevelop brownfields"[120] could easily be expanded into:

- *integrate industrial ecology/symbiosis with urbanism*

The rest of this thesis will attempt to address this final, visionary idea. Until now, both industrial ecology and industrial symbiosis have been primarily studied in terms materials, energy, quantified economic benefits, yet the bridge between them and urbanism is only beginning to be imagined. In order to successfully express a convergence between industrial symbiosis and urbanism, one must first understand the current state of industry in the United States.

## ***The Current State of US Industry***

Regional. National. Global. Decentralized. Agglomerated. Outsourced. Automated. All of these terms apply to the current state of industry in the United States. All also sound antagonistic to the cause of American industries exchanging anything to reduce resource and energy use. Clearly, it wasn't always this way. The current economies of scale, horizontal dispersal, and mega-supply chains have emerged for a variety of reasons. It is worth looking at what industries used to be, and what they've become.

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117 Ibid.
118 Lowe, Ernest A. "Creating By-Product Resource Exchanges; Strategies for Eco-Industrial Parks." Journal of Cleaner Production. 1997: 5(1/2); 57-65
119 Chertow, Marian R. "Industrial Symbiosis: Taxonomy and Literature." Annual Review of Energy and Environment. 2000. 25: 313-37.
120 Ibid. pg. 334.

As it currently stands, and vividly documented by Alan Berger in his recent book *Drosscape*, "manufacturing establishments are progressively relocating forty to seventy miles outside of their traditional central city locations."[121] Berger analyzed Atlanta, Boston Metro, Charlotte/Raleigh-Durham, Chicago, Cleveland, Dallas/Fort Worth, Denver, Houston, Los Angeles, and Phoenix and discovered that industrial agglomerations at this critical distance do so for clear reasons. "Industries and enterprises share various advantages of geographical proximity such as ease of transporting goods, infrastructure costs, tax incentives, manufacturing-related product...hav[ing] a symbiotic, regional relationship to older central cities where industrial production formerly occurred, although they visually and physically appear as disparate urban forms and locations."[122] Hence, the derivation of industrial "park", the agglomerations previously mentioned. Not only does this scale of operations require massive supply-chains to keep it running, it also demands extensive infrastructural conduits *lacking any relative adaptive capacity*.

As such, the combination of the above results in relatively low symbiotic desires at the scale of the industrial park, let alone between industry and city. At best, "eco-industrial park" becomes the highest attainable achievement – a positive yet small step within the larger vision of industrial ecology.

There is a massive intensity of resource and energy use to keep it all running smoothly – primarily cheap transport. In 2005, the United States industry sector used over 24 quadrillion BTU's of energy at 80% efficiency, with over 70% of its operational energy inputs derived from petroleum and natural gas.[123] These industrial agglomerations of scale are supported by a transportation sector consuming almost 28 quadrillion BTU's of energy at a very low 26% efficiency rate, and at an even lower cost.[124] Energy supply instability to the wind, the Energy Information Administration of the United States Government (EIA) continues with the following predictions. The industrial sector is slated for only minor increases in energy use through 2030 however; its supporting transportation sector will see great increases in energy consumption. The correlation between increasing liquid fuel use and energy use per dollar of industrial value of shipments is quite strong.

"From 1980 to 2004, energy consumption in the industrial sector was virtually unchanged; growing by a total of 3.1 percent, while value of shipments increased by 50 percent."[125] From an economic growth standpoint, one can see why the EIA continues to project increased cheap transport into the future; this entails no change in the current way operations work, equating to ever-increasing value of shipments from the industrial sector and supporting its current dispersed, regionally-agglomerated spatial relationship within the American landscape. It

[121] Ibid. pg 79.
[122] Ibid. pg. 56.
[123] Energy Information Administration. Annual Energy Outlook 2007. United States Government.
[124] Ibid.
[125] Energy Information Administration. Annual Energy Outlook 2007. United States Government. Pg. 79.

also becomes extremely clear why industrial symbiosis has such a difficult time rooting itself in the United States context – why exchange anything if all is well? (And, more importantly, all is conceived to continue to be well). If we are to examine future changes in the relationships of industry and region and the symbiotic capacities of each, the correlation between urban form and its fuel must be understood. Form has clearly followed fuel if history is to show us anything.

## *Form Follows Fuel[126]: Why Industrial Form is the way it is*

The relationship between industrial development, urban settlement, and energy use can be seen in changing spatial patterns of the city over time. While the Energy Information Administration only displays US energy data dating back to 1949, we can use this data to compare increasing energy use with changing urban settlement patterns. Historically, industry used to be the most energy consumptive sector of the US economy. Increased efficiency in production methods as well as automation has enabled it to level out; consolidation, agglomeration, and dispersal of industries in exurban locations has been fostered by rapidly increasing transportation energy use in the form of liquid fuels and mobility. Urban geographer Richard Morrill has studied and classified four major trends in the changes of the spatial development patterns of the American city: the mercantile city (to the mid-19th century), the industrial city (1820-1920), the spread city (1920-1970), and the current edge city (1970-present). We can compare conceptual models of each of these types and see distinct relationships between increased energy use and pattern change.

These transformations in urban spatial arrangement are clearly linked to trends in increasing energy use over time. So what? What does this mean if the EIA projections envision more of the same? It would be easy to profess that these trends will continue unchanged, thereby permitting designers of the built environment to focus on the detritus and vast left-over waste space created from such massive horizontal development as theorists like Berger and others proclaim. However, such a short-sided belief in 'more of the same' is naïve in its lack of consideration of the vast research currently available on the future of energy. Interestingly enough, this research sends a very different message, and its implications to future forms of city form and industrial symbiosis are staggering.

## *Energy Projections – Where we're headed*

Predictions are always subject to debate. The prediction of future energy supplies is an inexact science. Models are constantly revised. Data sources are often shrouded in secrecy. On top of that, there are so many vested interests; so

126 This phrase has recently been coined by Peter Droege in his book *The Renewable City*. Droege, Peter. The Renewable City: A Comprehensive Guide to an Urban Revolution. West Sussex, UK: Wiley-Academy, 2006.

much inertia against imagining things remotely different from how they currently are in an energy-intensive developed society that it plays heavily into future projections – no one ever wants to believe things may be different in a negative manner, only positive. The prediction of growing energy demand is a far more digestible concept – it is generally assumed that in order to achieve current definitions of progress, a nation must increase its overall energy and resource consumption to elevate its "standard of living". If we consider worldwide desire to follow this trajectory, it is assumed to look something like the following:

According to the Energy Information Administration of the United States Government, overall World energy consumption is projected to increase almost 60% in the period from 2003 through 2030. Much of this energy consumption is spurred by the rapid modernization and consumptive practices of developing nations such as China and India striving for Western levels of mobility, production, etc. in the years to come. Most fascinating about the EIA predictions is not the overall growth projected in energy consumption worldwide but the fuel types anticipated to pick up this slack to meet growing demand: non-renewables such as oil, coal and natural gas as opposed to renewables like wind, solar, hydroelectric, or biomass. Any observant individual can see these desires being played out today on the geopolitical world stage: the invasion of hostile territories to secure dwindling resources, the feverish pace of developing nations like China to secure energy futures contracts in far-off places ranging from Canada to Colorado. These actions suggest something different than the data above. Couple these actions with growing public concern over the pressing environmental issues of our time: global warming, water and food shortages, and rapid loss of biodiversity and we begin to see that projections like the one above are certainly not factoring in major issues capable of severely altering their vision of the future. The increase of World energy consumption at the above rates would generate astronomical amounts of waste, pollution, and environmental burden beyond the Earth's regenerative capacity. No matter how attuned industrial ecology/symbiosis may be to the reduction of human impact on natural systems, at this scale tremendous environmental degradation is inevitable. Cities and urbanization will always generate waste, yet at this scope there is currently no incentive to do anything about it, especially in the already developed United States whose entire minimally-adaptable built environment is predicated on massive energy inputs. We continue to operate under the assumption that existing, cheap, and available energy and resources will enable us to continue this lifestyle unaltered. We will not we see policies and practices such as industrial symbiosis put in place to deal with these issues at a grand scale until these fundamental roadblocks are ironed out. "There can be no sustainable development while fossil and atomic power sources prevail."[127] As such,

[127] Droege, Peter. The Renewable City: A Comprehensive Guide to an Urban Revolution. West Sussex, UK: Wiley-Academy, 2006. pg. 51.

approaching true limits may be the only way of catalyzing such energy and resource reducing policies to take root at a large scale. If we dig deeper into the current state of energy and resource supplies, such a time seems not far away.

## *Methodology: Limits as Incentives*

Industrial symbiosis is one tool for reconciling anthropogenic impact on natural resources. Its limited to non-existent success in the United States context has not been due to the fact that the 'attributes necessary for success' as conceived by its major proponents do not exist, but rather the entire means of industrial operations in the US offers no incentives for it to take root. Policy approaches aimed at its implementation often fail because of imbalanced economics regarding the pricing of disposing of wastes (there is still ample landfill space available in most places) and minimized energy use when more profit is to be made by searching out even more supply. Physical planning-based efforts for the implementation of industrial symbiosis, such as the whole list of PCSD case studies attempted in the mid 1990's, also failed because they didn't account for the complex physical, social, economic, and energy patterns embedded in contemporary industrial agglomerations found in the United States.

Future predictions of the peak production of oil and natural gas resources impose limits on the way industrial operations currently operate and arrange themselves within the landscape. They will act as triggers and filters to how industrial operations and more specifically industrial symbiosis will unfold in the near future in the United States. These predictions on the future of oil and gas can be broken down into three scenarios:

- *The Far peak*: promulgated by the EIA and CERA (Cambridge Energy Research associates, defines the peak of oil and gas production to be at least 30 years from now.
- *The Mid Peak*: this mid-range scenario projects the peaking of world oil production to occur within the next 10 years, and is supported by recent studies by Robelius and Laherrere
- *The Near Peak:* Based on studies by those like the Association for the Study of Peak Oil and Gas (ASPO) and Bakhtiari, the near peak data warns of production topping out within the next 3 years.

Each of the three scenarios will be used as a lens to view changes in industrial spatial organizations and the capacity of industrial symbiosis over time. Each scenario will be evaluated on the following parameters:

- Mobility of goods and by-products
- Symbiosis case study type
- Symbiosis opportunities
- Symbiosis constraints
- Symbiotic Facilitating Tools (physical and policy)

- Conduits
- Urban Form Implications
- Planning/Design Interventions
- External Pressures
- Adaptive Capacity
- Succession over Time

Each scenario will have descriptions of the above categories and ultimately recommendations will be made on how to interpret each approach in the context of future energy and resource supplies. Rounding out the chapter will be an analysis of future changes in industry types, the symbiotic capabilities of urban settlements, and means of the planning and design professions to ease the transition.

### ***Limits on the Limits***

These scenarios obviously have their limits, most noticeably in their exclusion of technological advances in increasing the supply of energy and the efficiency of their consumption. However, it should be noted that *demand* control is far more important in the context of industrial ecology, for technology applied with the intentions of increasing energy supplies can tremendously exacerbate overall waste and pollution outflows. As stated by Kibert, "reducing consumption is more important that increasing production efficiency as the change agent for industrial ecology."[128] The reality of peak oil is certainly one American society isn't prepared for and its occurrence will undoubtedly spur major investment into alternative means of energy; however, it is all about *timing*. As displayed by the short time spans of these scenarios it is highly likely peak oil will occur before technology has time to replace the resources of oil and gas based on current trends. There are no currently known amalgams of energy as potent and flexible. Thus, it is worthwhile to envision how industrial agglomerations (and the built environment) can begin to adapt.

Another constraint to this methodology is the relative general level of detail in analyzing an entire industrial sector of the US economy as disparate from region or place. Every region and the subset of industries it contains is different. Each one will have a particular set of built-in resilience tools to respond to future changes in energy and resources, and thankfully so. However, enough similarities exist between industries across America that it is worthwhile to envision how their larger patterns of development will respond and change.

Lastly, resource use data does not exist for any US metropolitan region or city and there are no standards for collecting such data. Therefore, envisioning place-specific means of mitigating resource and energy consumption is currently not an option. This is a large area in need of further study.

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[128] Kibert, Charles J., Jan Sendzimir, and Bradley Guy, Ed. Construction Ecology: Nature as the Basis for Green Buildings. New York : Spon Press, 2002. pg. 287.

## The Scenarios

First, an explanation of the sources of information regarding future oil and gas supplies: The Far Peak.

The Far Peak is envisioned by the Energy Information Administration, a division of the US Government's Department of Energy responsible for the collection and dissemination of data regarding past and future trends in the production, consumption, economics, distribution, and technology pertaining to energy reserves. It is also echoed by the energy think-tank Cambridge Energy Research Associates (CERA), which is headed by author Daniel Yergin who has written extensively on oil consumption and reserves.

Beyond the timescales assumed by these projections, there are two interesting facts to point out about this scenario. First, they do not subscribe to the bell-curve shape of finite resources as developed and proven by M. King Hubbert, but rather they assume a linear shape. This projection conflicts with Hubbert's modeling of US oil production which factually peaked in 1970 and was described in the introduction. Secondly, it assumes that demand will remain steady and be supplemented by increasing imports of petroleum and natural gas from other parts of the world, suggesting our forever indebtedness to nations who have questionable supplies of the resources and even more questionable political relationships with the United States entirely. These facts solidify the US Government's lack of preparation for the realities of resource constraints, making these predictions quite disturbing. Nonetheless, it will be included as the 'best case scenario' in terms of future energy supply and factors for industrial symbiosis to respond to.

The Mid peak suggests the topping-out of world oil production within the next 10 years. It is the most up-to-date projection supported by a study released in March of 2007 by Fredrik Robelius, member of the Uppsala Hydrocarbon Depletion Study Group, (UHDSG), and Uppsala University in Sweden. Others like Jean Laherrere, a petroleum engineer, geologist, and member of ASPO, and the Association of Petroleum Geologists share similar models. According to Robelius, "the worst case scenario shows a peak in 2008, while the best case peaks in 2013 although at a higher production level. The production in the best case scenario increases more rapidly than a future demand growth of 1.4 per cent. Therefore the production can be adjusted to follow the demand growth, resulting in a postponed peak oil to 2018. Thus, global peak oil will occur in the ten year span between 2008 and 2018."[129]

The Near peak is comprised of Robelius' 'worst case scenario' and the Association for the Study of Peak Oil's (ASPO) prediction that production tops out between 2008 and 2010 – within the next three years.

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129 Robelius, Fredrik. "Giant Oilfields: The Highway to Oil: Giant Oil Fields and Their Importance for Future Oil Production." PhD Dissertation. Uppsala University, Sweden. March 2007. Accessed 01 April 2007 from http://publications.uu.se/abstract.xsql?dbid=7625

The compilation of all projections can be found in. These scenarios provide the backbone to understanding how United States industry can adapt in the near future.

### *Scenario One – Far Peak*

Industrial symbiosis faces the same difficulties it always has in the United States assuming the EIA's projections are correct. The largest new catalyst for the formation of industrial symbiotic networks would actually come from external policies in other areas such as required carbon caps intended to address global warming, as well as the continued desires of industries to drastically improve their environmental responsibility image.

**Parameters**

**Mobility of Goods and By-Products:** Demand for mobility increases and is granted by continually low transport costs due to steadily increasing petroleum supply.

**Symbiosis Case Study Most Applicable to this Scenario:** The recently established National Industrial Symbiosis Programme in the UK operates as a nationally-scaled institutional framework with regional outposts capable of facilitating exchanges across vast geographic distance. It connects the dots between stakeholders previously unaware of potential users of their by-products.

**Symbiosis Opportunities:** Continuing unrestricted mobility enables exchanges over great distances (virtual industrial symbiosis). If firms cannot find a compatible user nearby, cheap transport costs can enable them to exchange their by-products with other firms located elsewhere in an economical manner, if regulatory, communication, and resource data collection tools are developed.

**Symbiosis Constraints:** Motivation for seeking out actual exchanges will continue to be very low. This situation is an extrapolation of current realities in which symbiosis has had a very difficult time rooting itself within the United States. There will also continue to be difficulty in the formation of effective organizations responsible for facilitating exchanges without major incentive creation or regulation.

**Facilitating Tools for Symbiosis**: Stable energy inputs will enable focus to be shifted toward completing material and energy data collection of metropolitan regions and cities to obtain clear visions of how resources move through their environments. This newly accumulated data will flourish with advanced communication technologies. Firms and organizations can harness the power of the internet and geo-spatial mapping tools to make all of their resource uses and needs publicly available online, encouraging self-promoted exchange networks.

Increased energy use will result increased waste and pollution generation, thus there will be no shortage of by-products and wastes to exchange. However, regulations are likely to be placed on carbon emissions responsible for global warming. These regulations could catalyze exchanges by making resource exchange a more attractive, economical venture, even in an non-energy constrained nation.

**Conduits**: Stable energy inputs will encourage continuing use of the existing conduits of contemporary infrastructure: interstate highways, regional inter-modal rail and freight, and pipelines spanning vast distances. If exchanges occur, they will utilize these conduits.

**Urban Form Implications**: Horizontal dispersal will continue. Regional agglomeration economies will persist. Industry will continue to seek out vast tracks of affordable land near transportation infrastructure at a sizeable distance from dense urban centers. In other words, existing trends will continue.

**Planning and Design Implications**: Both planning and design will continue to have very little impact on facilitating industrial symbiosis. Horizontal development patterns will continue to gobble up large tracts of land leaving even larger sections of waste landscapes. Contemporary urban design strategies such as landscape urbanism, (which speculates that landscape is the most effective building block of urbanism within present-day horizontally-dispersed, sprawling urban development patterns), will prevail as tools for dealing with the reconfiguration of left-over landscapes. There will continue to be increasing demand for mitigation strategies (such as effective stormwater management and ecologically sensitive site-planning) that cope with the burdens of expanded land development. Within this continually highly-mobile scenario, physical planning will continue to operate using current zoning laws resulting in land-use separation. Industries will continue to locate at the periphery where there is abundant, cheap land, and access to transportation infrastructure. Thus, physical planning and design continues to serve as a "screen" to cover up and make sense out of the detriments resultant of contemporary development patterns with limited ability to address the root drivers of waste creation.

Environmental planning policies will simultaneously need to be installed to control the flow and location of vast quantities of wastes and the location of their depositing to avoid large-scale environmental degradation. Landfill policies and recycling standards will continue to increase, but sill remain meager in their effect due to the ease of other waste disposal options. Transportation planning remains constrained by little demand for public transportation and continued personal automobile use. Much like today, its policies continue to chip away at the tip of the iceberg. Planning and design remains reactive, not-proactive in this scenario. More of the same.

**External Pressures**: As stated above, polices intended to mitigate carbon emissions and pollution will have backdoor impacts on supporting industrial symbiotic exchanges, product redesign, etc. Industries will continue to expand their desires for a more environmentally responsible image.

**Adaptive Capacity of the Built Environment**: This will remain very low. There is minimal incentive to view the constructed environment in terms of life-cycles of materials, resources, and energy flows. While this scenario is based on the peak being a few decades away, the consistent lack of foresight built into this form of development will create an incredibly difficult transition once peak oil and natural gas becomes imminent.

**Succession**: An abrupt, stark change akin to the burning of meadow or forest will be required to facilitate major change in this development pattern. The 'climax community' of sustainable development is far from approachable without this cataclysmic change.

### *Scenario Two – Mid Peak*

Based on projections of oil and gas production peaking around 10 years from now, this scenario could ultimately lead to conditions fairly conducive to industrial symbiotic networks if acted upon in a timely manner.

**Parameters**

**Mobility of Goods and By-Products**: A slow but steady increase in transport costs will begin to reshape mobility patterns affecting contemporary industry. While certain goods will still be marketed at great distances for some time, this will slowly give way to a decrease in the spatial reaches of industry. Costs for goods from greater distances will be much higher with time.

**Symbiosis Case Study**: Triangle J Council of Governments, North Carolina. This six-county region aimed to create potential exchange networks amongst is industries via geo-spatial databasing and resource inventory/matching.

**Symbiosis Opportunities**: Both virtual (albeit regional) and direct symbiotic opportunities. Markets will adjust such that it is more economical to begin to exchange resources depending on a region's surplus or shortage of any given resource, or good. This in turn can foster enhanced communication networks of increased trust and openness, facilitating exchanges.

**Symbiosis Constraints**: Regional capacities will begin to reshape the concept of 'anything made anywhere' into a higher level of regional production specificity. This could either be an opportunity or constraint depending on proximity between parties engaged in an exchange. Industries will need to re-format for more specified means of production, thus, postponing the search for exchanges because of time spent adapting.

**Facilitating Tools for Symbiosis**: Data management and resource tracking capabilities could play a major role in information transfer. This information availability could be a major catalyst to symbiosis due to the fact that mobility will be more expensive. Firms and organizations can harness the power of the internet and geo-spatial mapping to make all of their resource uses and needs publicly available online, encourage self-promoted exchange networks. Policies can begin to create incentives for exchange, furthering the promotion of symbiotic relationships.

**Conduits**: Conduits will most likely comprise of a hybrid of existing and newly modified/created infrastructures. Desired increases in efficiency will rescale transport options from large, clumsy trucking operations to more sleek and maneuverable options like those currently found in Europe. Increased investment in electrified freight rail could expand this conduit due to its energy savings and load capacity.

**Urban Form Implications:** Land values will begin to shift due to the increased costs of production and transport. The rich will still hang onto far-flung ex-urban developments for a period of time; however the middle-class and especially the poor will be forced to reconsider their proximity to work and other necessities and begin to migrate from lower value ex-urban developments into expanded urban infill opportunities. This will free up land at the perimeter for newly regionalized industrial operations relocating at the interface between urban center and its supportive hinterland.

**Planning and Design Interventions**: Planning and design will begin to play a critical role in transitioning land use patterns catalyzed by rising energy costs. Overall, this scenario will call for the formation of sustainable urbanism and supportive ruralism/agriculture: Living and working areas will become much closer spatially. While advanced telecommunication and internet technologies will still enable some separation in this regard, major retrofits of current land use patterns will be needed in order to re-localize certain supporting elements of human habitation. One such element is food production and agriculture. Due to increased transport costs, regional zones of agricultural production will become more prominent and fiercely linked with settlement patterns. It will no longer be economical to ship items from 3000 miles away. As mentioned above, mid and lower income developments at the fringe will become less viable and ultimately shift inward and/or densify, thus freeing up potential land for agricultural purposes. Each of these changes call for a major rediscovery of regional planning in the United States, which is currently almost non-existent. Regional planning could become the armature for which cities and their supportive agricultural hinterlands could develop effectively in balance in the face of resource constraints by distributing the burden over a larger geographical region and managing it with newly cooperative organizations and regulations.

Regulatory structures must be altered to enable this rebirth of regional planning. Current laws prohibiting the collective, comprehensive use of natural resources such as waterways and forests will need to be re-examined. Land use zoning currently prohibiting the co-location disparate land uses will need to be modified as well. Organizational structures regarding land development and retrofitting will need to develop metropolitan, regional, and state alliances in order to effectively allocate limited resources. Development will be much more focused on retrofitting rather than new construction.

There will be opportunities for planners to fill growing demand for these retrofit projects with local labor, thus offering potential for equitable economic development and job creation. Regulations and organizations pertaining to these workforce opportunities should be established very early on. Effective regulations on affordable housing transit oriented development must also be developed. Such energy constraints can make present-day lofty goals of planners become reality and common practice.

At a finer grain, urban infill development will become a way to cope with increased mobility costs, offering quality living at decreased distances from daily needs. Industry will begin to reshape itself at the interface between city and hinterland, moving inward but not entirely re-woven back into the fabric of the city. With it will come the need for re-established conduits and/or modifications of existing ones. Reshaping urban and industrial infrastructure will become a major planning and design focus. Symbiotic opportunities can be embedded into the very beginning of these shifts.

**External Pressures**: Major policies will have to be enacted to prioritize a smooth transition from the current energy and resource intensive existence to more sustainable practices brought on by reduced energy and resource availability. Most of which would be conducive to symbiotic networks, emphasizing resource maximization and energy conservation and efficiency. Economics would become the primary pressure to encourage resource exchange.

**Adaptive Capacity of the Built Environment**: This scenario could ultimately end up in a highly stable equilibrium depending on the policies and urban reformations enacted early in the transition. This is why planners are essential from the beginning of this transition process. The model of vibrant, efficient, urban centers with regionally-sensitive industry at the interface between city and hinterland should strive for a fluid and flexible relationship.

**Succession**: This scenario at its best case would resemble the natural succession of ecologies morphing toward a self-sustaining climax community over time.

### *Scenario Three – Near Peak*

Industrial ecology and symbiosis by default. Projections calling for the peaking of world oil and gas production within the next 3 years would set contemporary industries into a major scramble to find and develop coping mechanisms. Timely, forward-looking policies and interventions operating on coherent decisions about the allocation of resources will be imperative.

**Parameters**

**Mobility of Goods and By-Products**: To be clear, in this scenario, all mobility will not grind to a halt. However, its timing would be so inopportune and our general lack of preparation would force a major re-prioritization of what needs to be produced, where/what a goods source materials are derived from, and where the good ultimately ends up going after it is produced. Major mobility cost increases would undoubtedly demand massive change to a built environment entirely predicated on cheap and abundant fuel sources with little adaptive capacity.

**Symbiosis Case Study**: Kalundborg, Denmark. The original industrial symbiosis comprised of physical resource exchanges permitted by close physical proximity and environmental limits.

**Symbiosis Opportunities**: Symbiosis would almost certainly become an economical option due to limits on the cost of moving goods and by-products over vast distances. Depending on the change required in spatial relationships between city and industry, symbiotic exchanges could possibly occur between the two due to this scenario, expanding land-use types and actual resources exchanged. District heating for a city derived from excess heat exported by its industries is an example of this.

**Symbiosis Constraints**: The current staging, scale, and dispersal of contemporary industry would be the initial constraint until industries had to time to adapt to spatial arrangements more conducive to exchange. Transportation costs would rise so sharply that industries may not want to transport any wastes, thus re-instating the practice of "backyard dumping". Regulations to prevent this must be established very early on.

**Facilitating Tools for Symbiosis**: The non-subsidized, appropriate costing of the invaluable resource of oil would set firms into an intense search to minimize transportation costs; thus increasing the attractiveness of establishing symbiotic networks. Quickly enacted policies could add incentive to this.

**Conduits**: Conduits would be comprised of a hybrid of existing and newly developed interfirm/inter-city linkages. Urban waterways could see extensive use for moving goods, conflicting with current waterfront residential development priorities.

**Urban Form Implications**: Take the previous scenario and multiply how quickly it happens. Also, older centrally-located urban sites may become more suitable for industry considering they were once located near multiple conduits for a reason. Overall, there will be a massive shift in land values and extreme retrofitting of current development patterns due to industries needing to co-locate with one another and within proximity alternative means of transport.

**Planning and Design Implications**: Planning and design would have the most work to do if this scenario were to unfold, although much of what'd occur in response to tremendous increases in transportation costs would be ad-hoc and not driven by professionals. Extensive retrofitting of a built environment based entirely on cheap and abundant fuel would demand extensive overhaul. New industrial agglomerations would emerge in two different types, both requiring retrofit. First, and as mentioned in scenario two, the freeing up of land at the exurban fringe once occupied by lower and middle income housing would offer prime sites for industry. This switch from primarily suburban residential to industrial development would require architectural and infrastructural retrofitting, with industry locating at the interface between densifying urban settlements and increasingly regionally-productive agricultural hinterland. The second industrial agglomeration would be the reinsertion of industries into the urban fabric, utilizing sites where industry was once located prior to globalized supply chains fostered by cheap mobility. This creates many opportunities and obstacles for planning and design. First, an abrupt mentality switch must occur – most urban post-industrial sites are currently heavily contaminated brownfield sites, residue of previous industrial eras; and, if these sites have been cleaned up, as many have, they often become prime residential and commercial real estate offering waterfront views. The west side of Manhattan is a prime example. The extreme increase of mobility costs as supported by the energy data forming this scenario would require industrial production to relocate to these sites because of their proximity to both water conduits and markets. Reweaving industry into urban areas would require major rezoning and displacement of newly constructed residential and commercial structures. Planning and design would be responsible for mitigating conflicts between industry and non-industrial land-uses through landscape and built buffers, and noxious-use mitigation via by-product exchange permitted by industrial symbiosis. Planners should consider the numerous exchanges (such as excess heat or graywater reuse) between industrial and non-industrial use sited within close proximity of one another.

Symbiotic relationships could be embedded from the onset, and most likely would begin to occur on their own even before anyone could even plan them out. Overall, contemporary, parcelized land-uses and zoning would give way to major use overlaps, including the reinstatement of the once cheap energy-disabled land uses such as urban agriculture. Regional and local production would again have major importance in the proliferation or failure of any given region.

The largest constraint facing planning in this scenario is the collapsed time frame it'd occur in: there may be no time for planning and design decisions to adjust to changes primarily driven by necessity, and thus performed in an ad-hoc fashion as opposed to professionally delivered, top-down regulatory structures.

**External Pressures**: All of this envisioned land use overlapping is so starkly different from current practices that land-use compatibilities would become a major point of conflict. Advanced land-use interface design would become essential.

**Adaptive Capacity of the Built Environment**: Unfortunately, due to the massive changes put into the retrofitting of the current built environment, this new form would also have to grow and change in time as well. The city will be resilient, yet the compressed timescale of this scenario showcases our unprepared-ness.

**Succession**: This rapid form of change would be akin to rushing from an initial, colonizing to climax community in an incredibly compressed timeframe, skipping the transitional stages in-between.

## *Synthesis*

While scenario one is listed and should be considered, scenarios two and three seem to match current events much more closely, and thus, preparation should already begin. Planners have an extensive role to play in this preparation, with a host various tools to facilitate industrial symbiosis within each context. These tools, their various scales of operation and time sensitivities will be discussed in the following, final chapter.

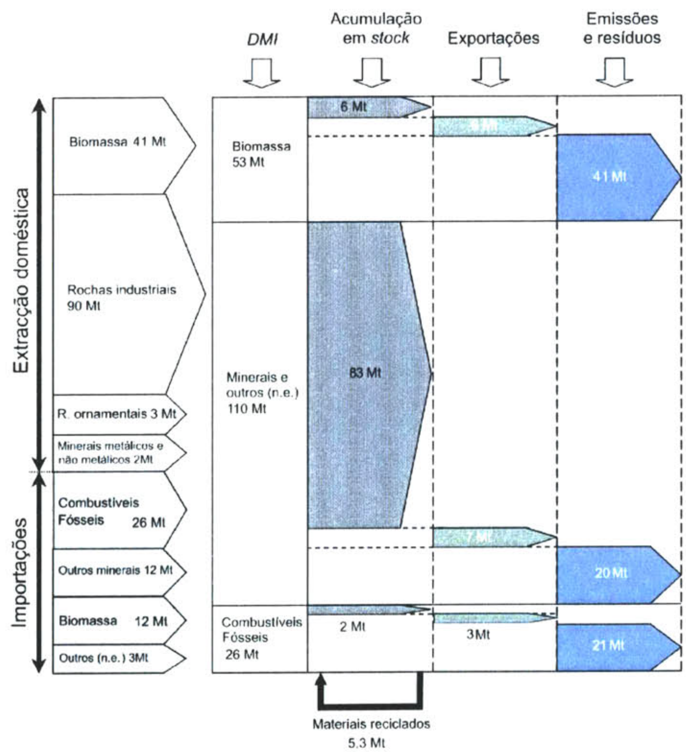


**Figure 34: The quantification of material and resource flows throughout the country of Portugal.**

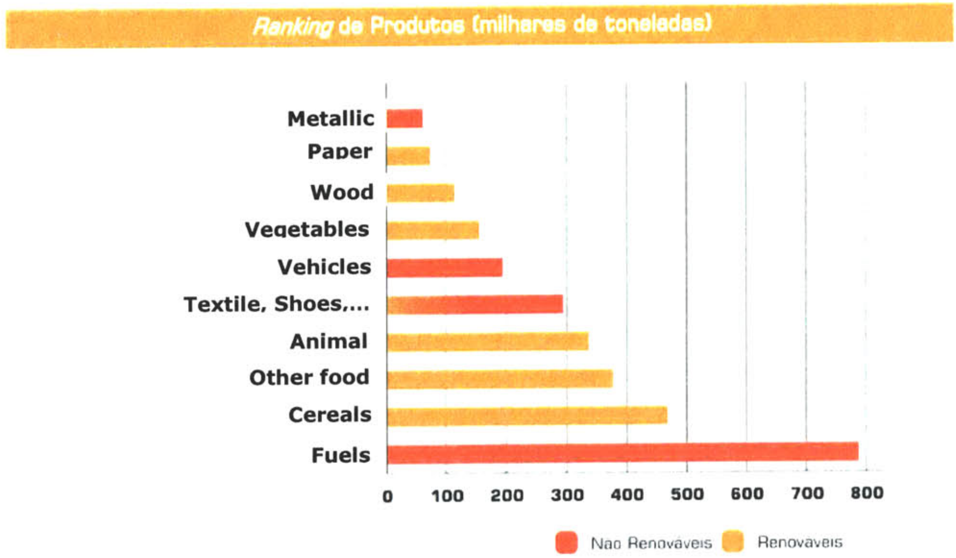


**Figure 35: Industrial Metabolism of the City of Lisbon, Portugal.**[130]

[130] Ferrão, Paulo Cadete. "Economy Metabolism: An Industrial Ecology Perspective." Lecture given 14 March 2007 at MIT. Technical University of Lisbon, National Director of the MIT-Portugal Program.


**Figure 36: Comparison of old and new industry agglomerations.**[131]

| U.S. transportation and energy infrastructure. Landscape statistics | |
|---|---|
| Petroleum-product pipeline | 152,000 miles |
| Natural-gas transport | 340,000 miles |
| High-voltage electrical-transmission lines | 154,503 miles |
| Electrical-transmission lines constructed annually | 1,000 miles |
| Railways, rail yards, and parallel lines | 178,000 miles |
| U.S. National Highway System | 160,000 miles |
| Waterways used for commerce | 12,000 miles |
| Airport locations | 19,500 |

**Figure 37: The massive network of conduit infrastructure in the United States.**

[131] Images adapted by author, photographs originally of industrial agglomerations within Ohio. Original source photographs from: Berger, Alan. Drosscape: Wasting Land in Urban America. New York: Princeton Architectural Press, 2006.

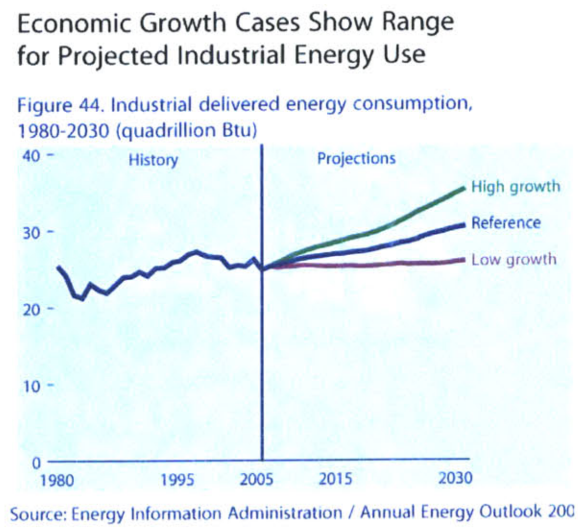


**Figure 38: EIA projected energy use, 2007-2030.**

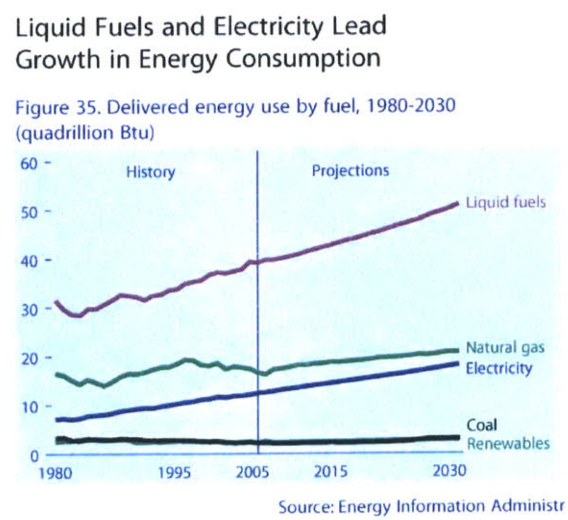


**Figure 39: EIA Projected Liquid fuel consumption, 2007-2030.**

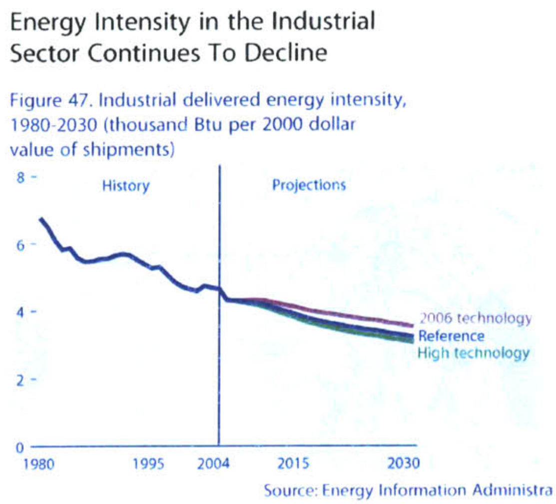


**Figure 40: EIA projected industrial energy intensity, 2007-2030.**

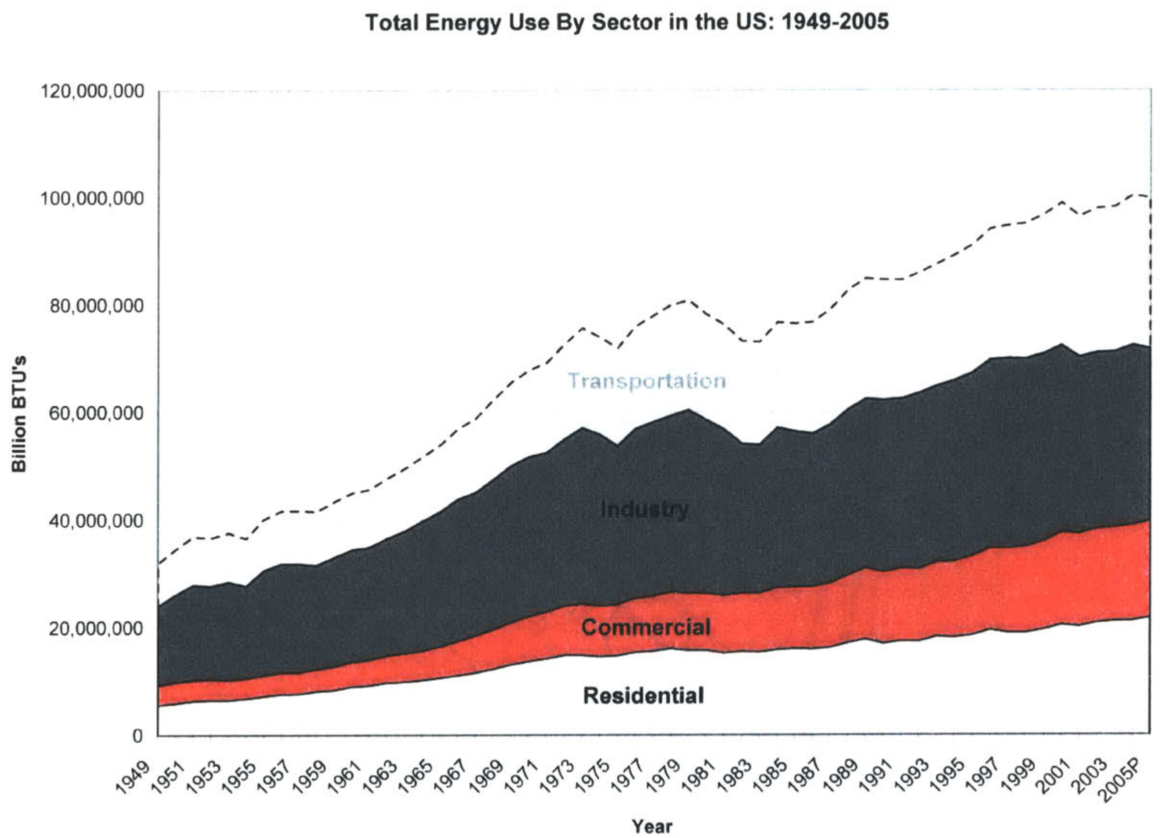


**Figure 41: Total energy use in the US by sector, 1949-2005. Source: EIA data.**

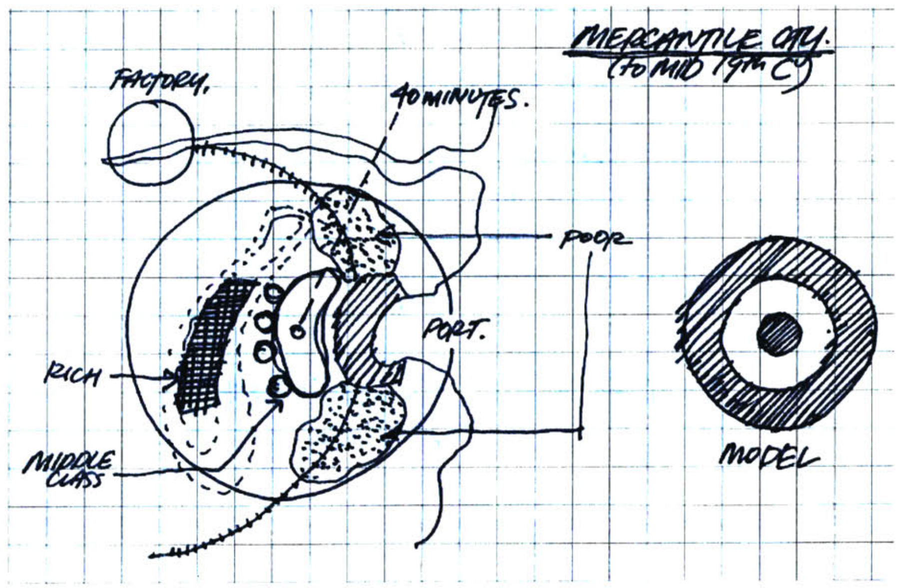


**Figure 42: The Mercantile City (up to mid 19th Cent.) - low energy, industry location based on conduits such as water and rail**

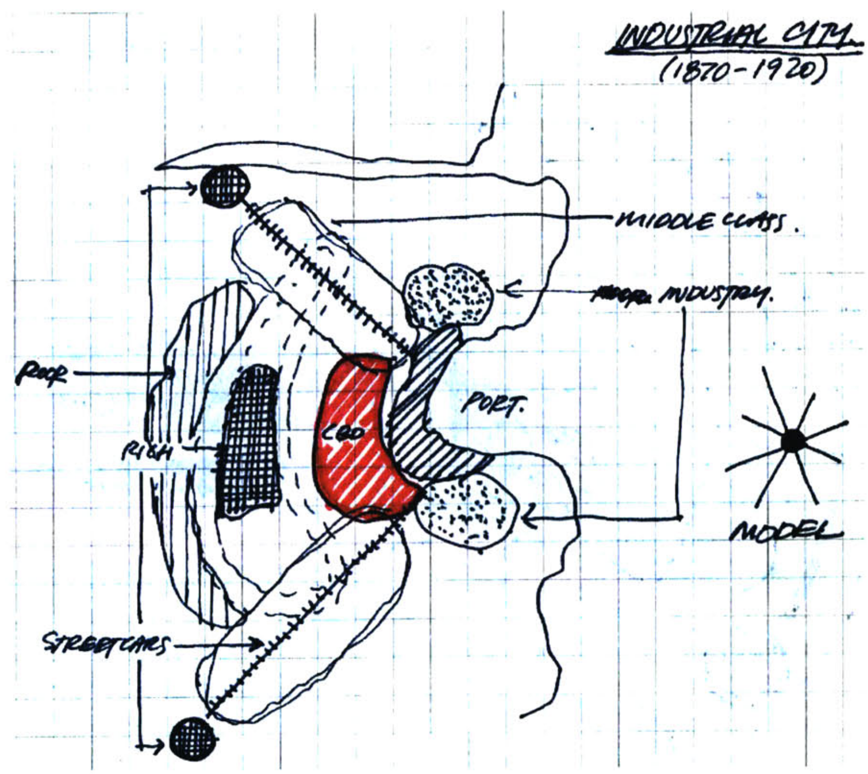


**Figure 43: The Industrial City (1870-1920) showcased Industry as the most energy intensive land use, still located near conduits like rail and water…however, cheap mobility would soon follow…**

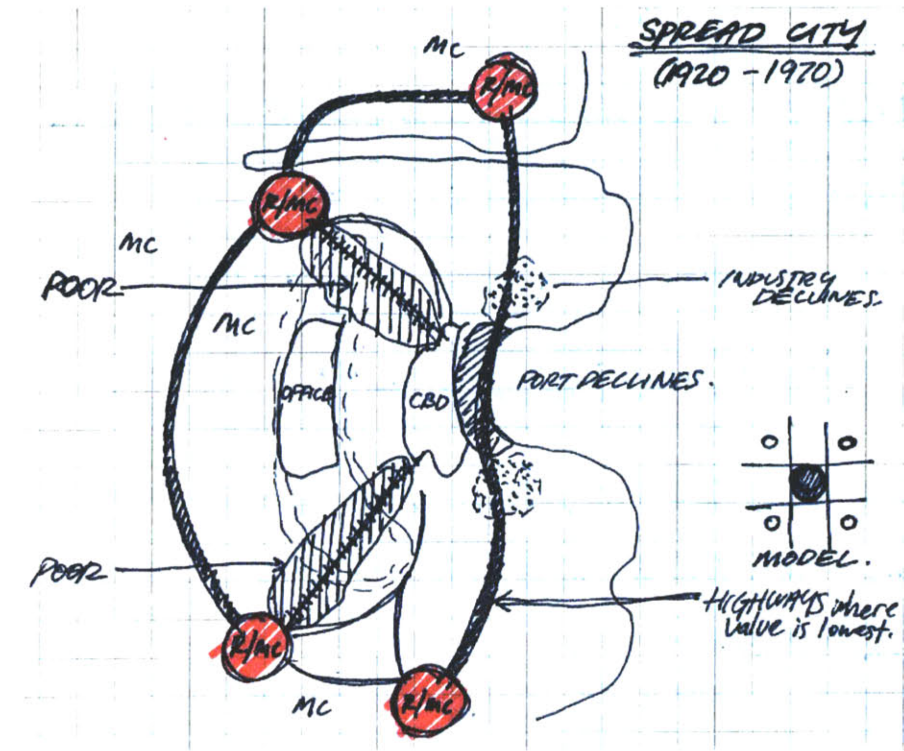


Figure 44: The Spread City (1920-1970) displays where transportation energy use surpasses industrial energy use, thus enabling industry to decant itself outside of the city

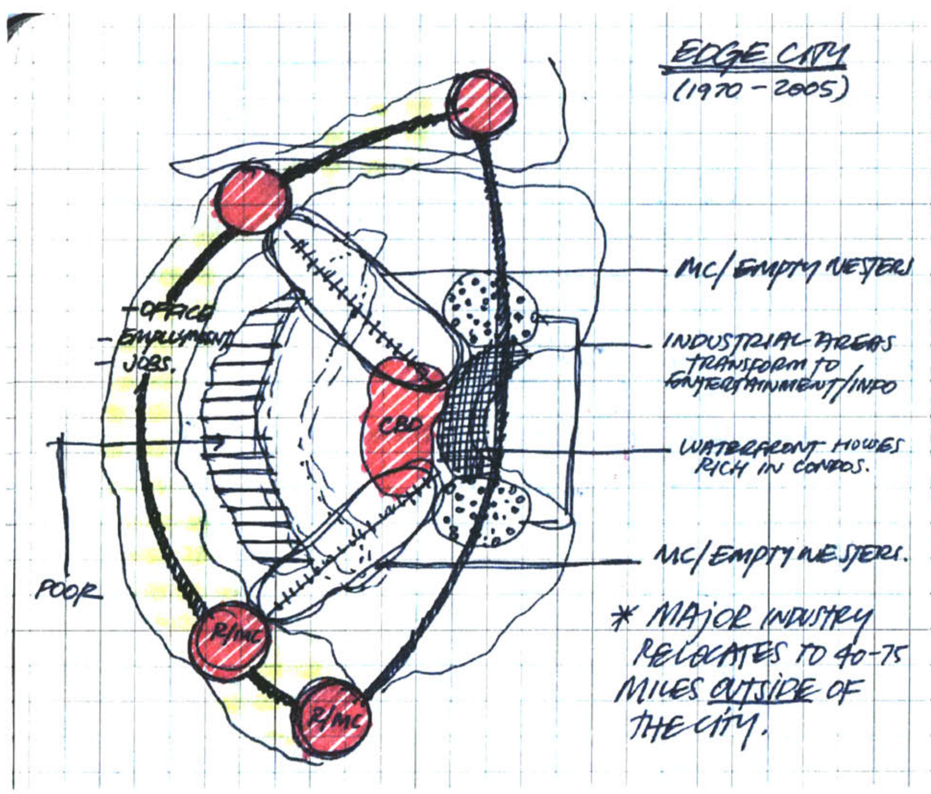


Figure 45: The Edge City (1970-2005) has seen massive gains in mobility due to increased transportation energy expenditure, enabling contemporary industry to agglomerate 40-70 miles outside of the city

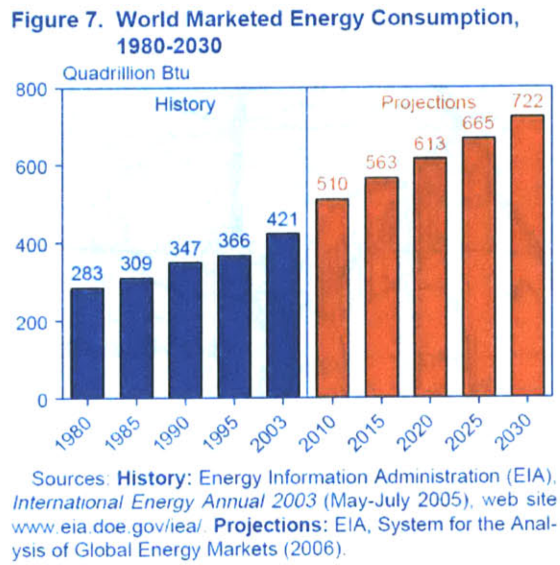


**Figure 46: EIA projected growth in World Energy Consumption through 2030.**

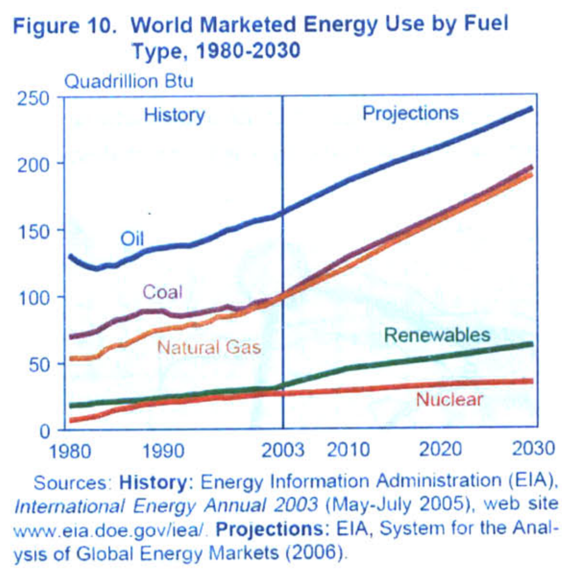


**Figure 47: EIA Projected growth in energy use by fuel type through 2030.**

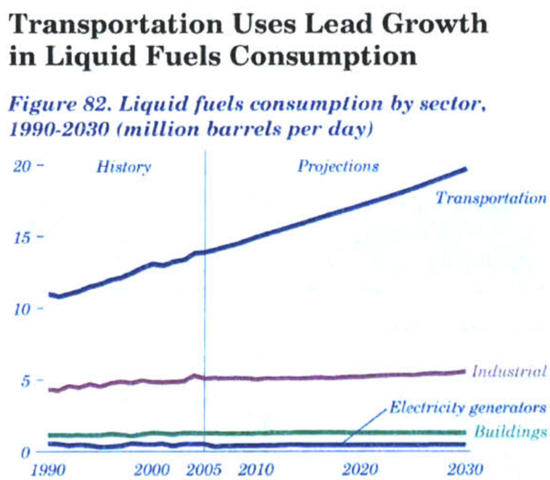


**Figure 48: EIA projected growth in Liquid Fuel Consumption in the Transportation Sector through 2030.**

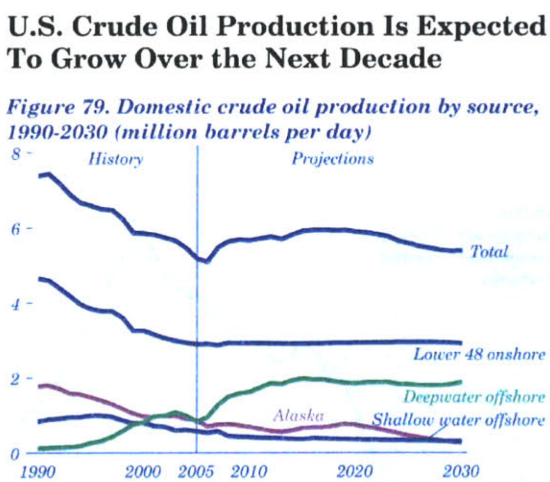


**Figure 49: EIA project change in US Crude Oil Projection through 2030.**

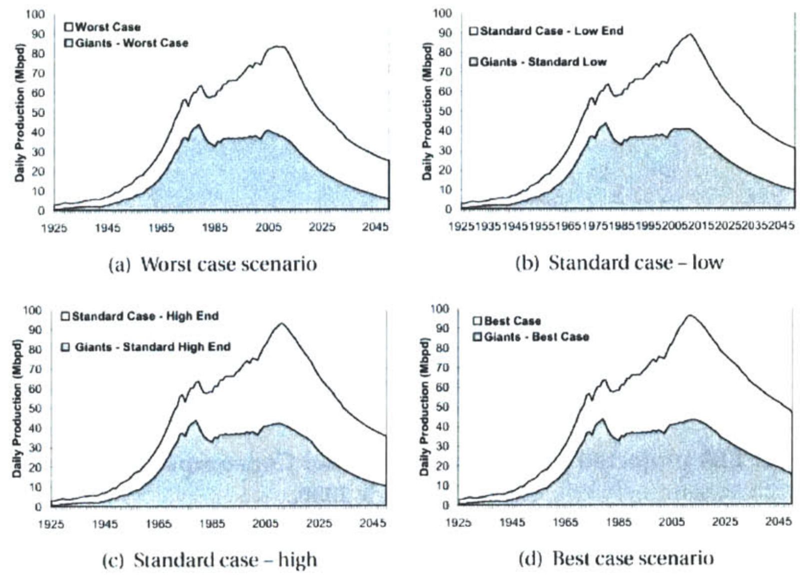


*Figure 9.3:* Future oil production, in million barrels per day (Mbpd), for each scenario and the contribution from the giant fields.

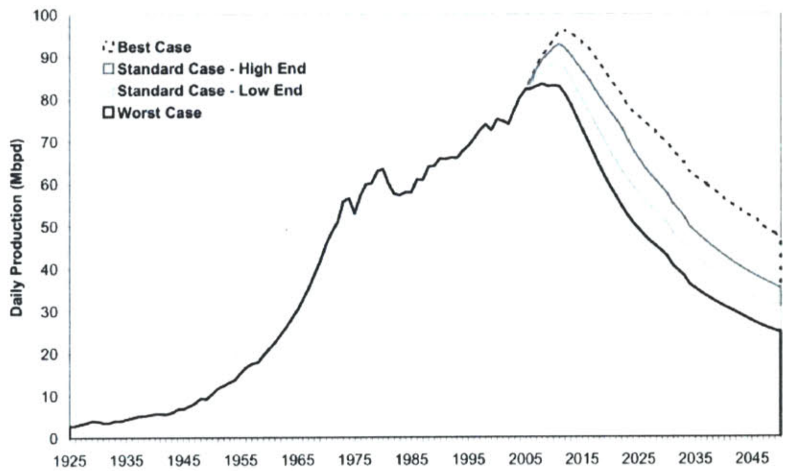


*Figure 9.4:* Global liquids production, in million barrels per day (Mbpd), in the four different scenarios.

**Figure 50: Contrasting Peak Oil projections based on remaining giant-oil field analysis released in March 2007 by Frederik Robelius, Uppsala University, Sweden.**

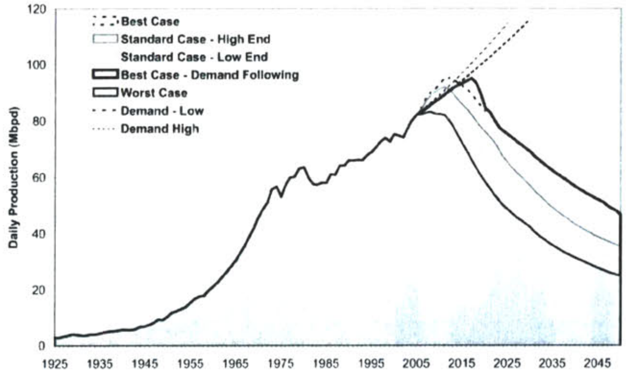


*Figure 9.5:* Global liquids production in million barrels per day (Mbpd) for all scenarios, with the best case scenario adjusted to fit an annual demand growth of 1.4 per cent.

**Figure 51: Scenarios for the future of Oil and Gas released March 2007 by Fredrik Robelius, Uppsala University, Sweden.**

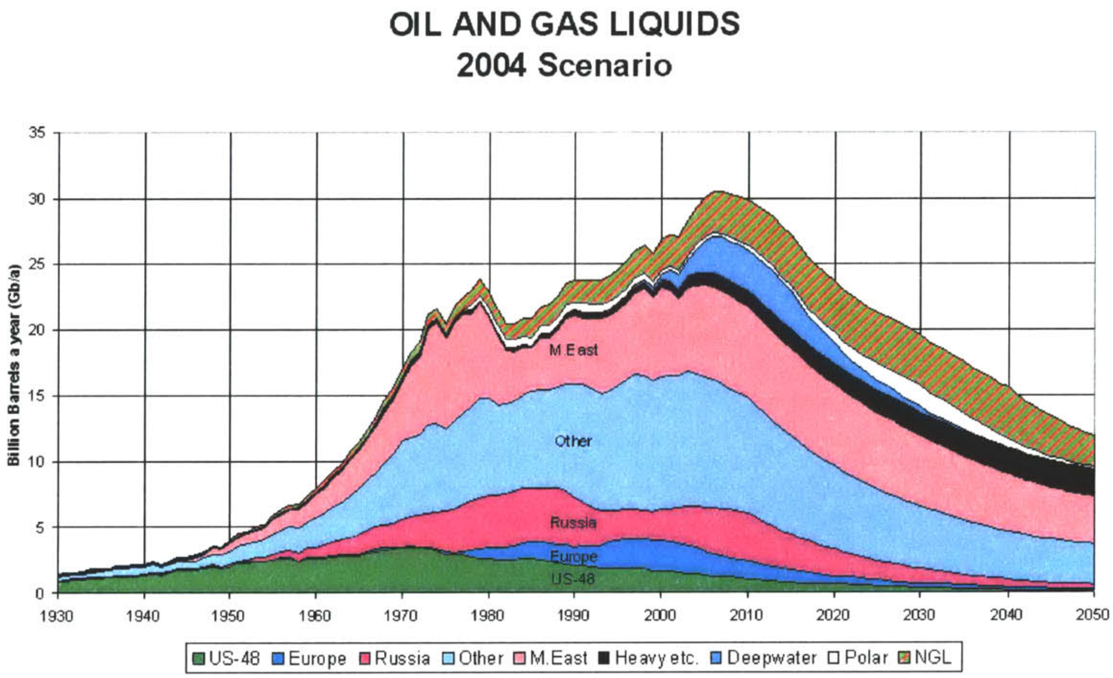


**Figure 52: ASPO projection: 2010 peak[132]**

132 ASPO. Association for the Study of Peak Oil & Gas. Accessed 19 March 2007. http://www.aspo-usa.com/

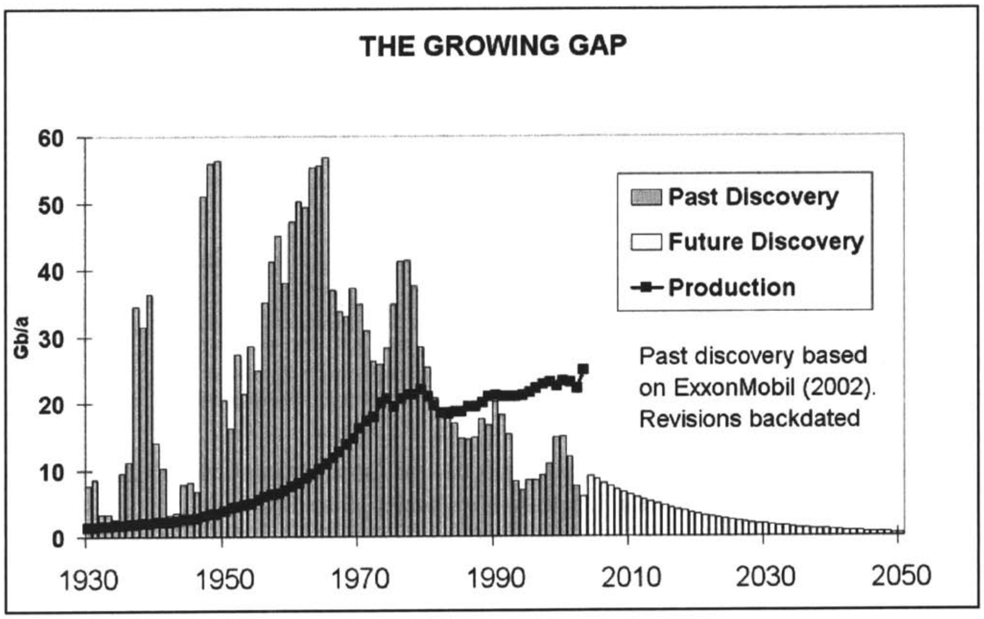


**Figure 53: ASPO graphic of gap between oil field discovery and production.**

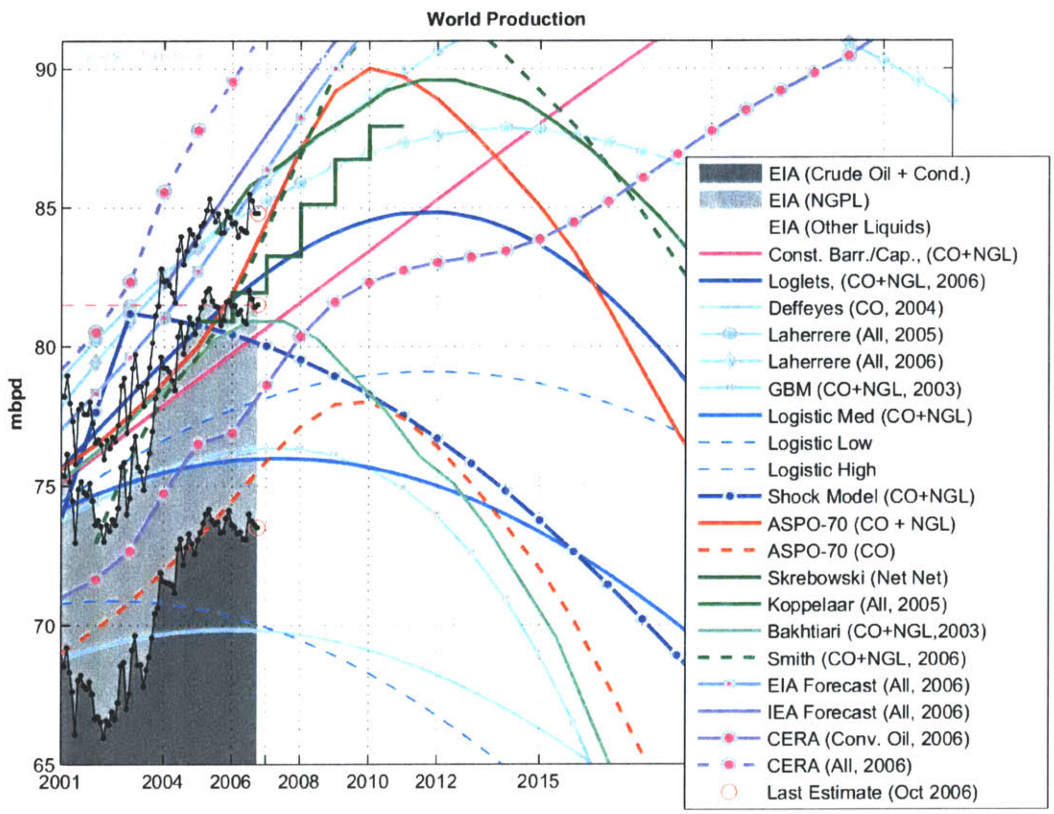


**Figure 54: Compilation of World Production Peak Projections - August 2006**[133]

133 http://www.theoildrum.com/node/2143 accessed 02 April 2007.

| **SCENARIO** | **LONG** [EIA, CERA forecasts ~30yrs] | **MID** [Optimistic Peak ~10yrs] | **SOON** [Pessimistic Peak < 5 years] |
|---|---|---|---|
| **Mobility of Goods, By-Products** | High [continually low transport costs] | Mid [slow but steady cost increase] | Low [rapid cost increase] |
| **Symbiosis Case Study Type** | NISP [UK]: National-Regional Facilitation Body | Triangle J [NC]: Regional | Kalundborg [DK]: Urban Symbiosis; Local |
| **Symbiosis Opportunities** | Exchanges capable over great distances [virtual] | Virtual and Non-Virtual Capabilities | Non-Virtual exchanges greatly needed |
| | Multiple outlets over different geographies | Regional Exchanges Encouraged | Industry-City exchange opportunities |
| | | Communication fostered by proximity | Communication fostered by Proximity |
| **Symbiosis Constraints** | Organizational difficulty | Regional Capacities/Limits | Regional Capacities/Limits |
| | Motivation for actual exchange | Industry Relocation/Re-formatting | Industry Relocation/Re-formatting |
| | | Land Use Shifts | Urban Industrial Land Use Compatability |
| | | | Zoning restructuring |
| | | | Industrial Energy inputs limited/different |
| **Conduits** | Existing Infrastructure: Truck/Highway/Freight | Hybrid of Existing Infrastructure and | New and old non-virtual [pipe, water, rail] |
| | | new non-virtual conduits | |
| **Urban Form Implications** | Horizontal Dispersal Continues | Regional City/Hinterland relationships | Industry Re-inhabits Historical Posts |
| | | | Older, denser conduits desired |
| **Planning/Design Interventions** | Reconfiguring of Interstitial, Left-over Landscapes | Re-densification of City and 1st ring | Industry relocation/re-urbanization |
| | Landscape Urbanism | suburbs; Industry re-inhabits edges of | Zoning restructuring |
| | Drosscape | cities and exurban developments, | Advanced Industry/City interface design |
| | Organization/Policy Creation | interface between rural and urban | Noxious Trait Mitigation |
| | | Urban Infill - Housing, etc. | Urban Infrastructure/Conduit Dev't |
| **Adaptive Capacity** | Low? | High? | Mid? |
| | little need for adaptability | flexible urban/rural inerface/relationships | |
| **External Pressures** | Carbon Offsetting | Carbon Offsetting | Land-Use Compatabilities |
| | Pollution/Waste Policy | | Scale requirements |
| **External Facilitators** | Rich Information, Databasing and Tracking | Rich Information, Databasing and Tracking | Rich Information, Databasing and Tracking |
| | Dematerialization | Pollution/Waste Policy | Pollution/Waste Necessity |

**Figure 55: Projected Scenarios affecting industrial symbiosis over time. Source: Author.**

# Chapter Five

*"History can predict nothing except that great changes in human relationships will never come about in the form in which they have been anticipated."*
*- Johan Huizinga*

## Major Opportunities and Constraints concerning the future implementation of Industrial Symbiosis

The state of industrial symbiosis in the United States is on the cusp of major change. Full blown industrial ecology and symbiosis can't and won't happen in the U.S. until the previously discussed scenarios of trends in energy and materials come to fruition and demand an entirely new paradigm; there is currently far too much inertia in current practices, economics, and other non-exchange friendly methods to foster a symbiosis encouraging climate. However, the proposals of industrial ecology and symbiosis have built up sufficient theory and experience through application to step up and become the model of future industrial operations once raising energy, mobility, and material costs force industries to adapt. Planners have the necessary skills to help transition to this new model if they are poised to be in the "right place at the right time" and to utilize a variety of tools and approaches. Before describing what these tools are, a recap of reasons why the ideas of industrial ecology and symbiosis haven't taken off at a large scale in the United States is in order:

**The Big Issues**

- Mobility and transportation costs are still extremely low, thus discouraging exchange fostered by proximity
- Precious resources are under priced and subsidized to an extreme degree, which discourages re-use and efficiency
- Relative ease and ability of waste "disposal" as opposed to re-use.

**Issues more easily addressed**

- Lack of *visibility* of benefits of exchange (and the exchanges themselves) currently underway
- No data collection *standards* for resource, energy use, and by-products
- No full utilization of available *communication* networks – relatively little intra-firm communication or mechanisms to encourage
- Long-term *limits* and changes in resources and energy non addressed

As discussed in detail in the foregoing chapters, the big issues are changing rapidly. The amount and rate of change over time within these categories, which will be imposed by natural limits and policies, will create the three previously mentioned far, mid, and near-peak oil scenarios within which industrial symbiosis facilitators will operate.

There are four steps to be taken to promote the widespread implementation of industrial ecology in the U.S., given that changes in the 'big issues' are inevitable. Each step is described below in ascending amount of time and effort needed to put it into practice:

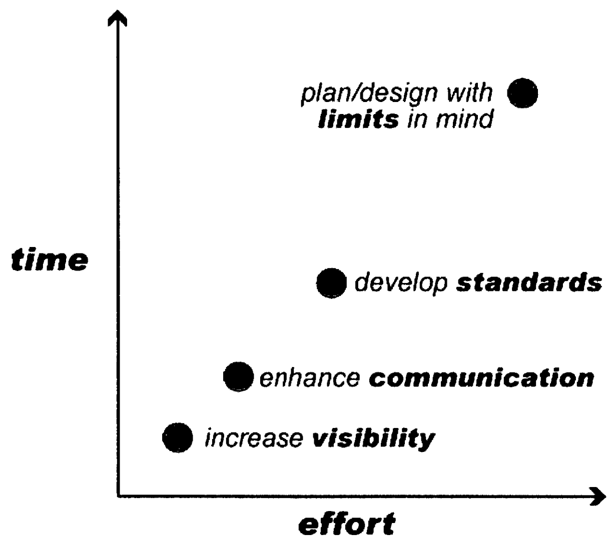


**Figure 56: Scale of recommended actions to facilitate symbiosis. Source: Author.**

## ***Recommendations for advancing and adapting Industrial Symbiosis in the United States***

**STEP ONE: Increase the visibility of the benefits of industrial symbiosis at multiple levels.**

Industrial symbiosis is already occurring with varying degrees of success within the U.S. already, however, very few people know about it. Sometimes this symbiosis is as mundane as a warehouse using a makeshift sign exclaiming "we buy wood pallets." Industries unknowing of the quantified economic and ecological benefits offered by exchange must be addressed via industrial symbiosis "champions" such as the UK's National Industrial Symbiosis Programme (NISP) or the regulatory organization about to be described in the next step. Even larger steps to increase visibility need to be taken after the implementation of a symbiotic exchange network. Industrial firms are currently interested in increasing their "eco-responsibility" and environmental image in the public eye, yet no tools are developed for industrial symbiosis to become a visible tool for achieving this responsibility. Industrial symbiosis is rarely found in the environmental (or economic for that matter) marketing campaigns, even of those firms who have incorporated its practices. Approaching individual firms and plugging into the desire for a responsible image could undoubtedly garner funding for the establishment of symbiotic practices. Other tools to enhance visibility should be exploited as well. The internet offers a prime opportunity to increase visibility, as case studies like NISP have already taken advantage of it. Planners can easily fill the role (and some already have) of becoming symbiosis champions dedicated to increasing the public visibility of the benefits of resource exchange networks.[134] In total, doing so could be the simplest, most easily attainable step taken to create the largest positive impact in the shortest amount of time.

**STEP TWO: Establish an Advanced Web-Based Data/Information/Communication Tool: The Internet Based Symbiosis Networking Tool.**

Inspired by the Triangle J and NISP case studies, the purpose of this website would be to facilitate cross-industry communication regarding the exchange of materials, resources, energy, and expertise utilizing current, accessible, advanced networking technologies hosted online. It could become a hybrid of popular social networking sites such as Myspace and Facebook, online GIS/geospatial information delivery interfaces, material flow analysis and resource lists for matching industry needs and availables (a scientific craigslist), all interwoven with XML/RSS tools (see footnote) for real-time symbiosis information.[135] (Figure 57)

Potential features of the website communication tool:

- **Geospatial Industry Analysis matched with Material Resource Data-basing and Categorization**
    - Expanding upon the early precedent of Triangle J Council of Governments industrial symbiosis study in chapter three.

- **Needed materials and energy (imported by-products)/Available materials and energy (exported by-product) lists**
    - Once data is collected on actual resource usage, industries could advertise the quantities and types of both needed and potentially exported resources available for symbiotic exchange.

- **Re-use Identification and Material Capabilities**
    - This is a section devoted to spelling out all of the ways that materials and energy could be re-used currently.

134 See the Devens Case Study Example in Chapter Two.
135 RSS is an alternative means of accessing the vast amount of information that now exists on the world wide web. Instead of the user browsing websites for information of interest, the information is sent directly to the user, and is continuously updated in real-time.

- **Needed Conversion Technologies/Industries**
  - Needed technological developments for expanded future material and energy re-use options would appear here.

- **Point-person contacts**
  - This contact list would promote key personnel within an industry, city, and/or region to communicate with if interested in resource exchange.

- **Logistics information regarding by-product mobility options**
  - Contact information regarding the physical movement of by-products, and/or listing of existing and potential conduits.

- **Exchange Savings Cost Analysis/Calculator**
  - Up front and center should be a real-time cost analyzer, estimating potential savings for engaging in symbiotic resource exchange on a by-material and energy source basis.

- **Real-time monitoring and accountability (RSS feeds of material flows and exchanges)**
  - Monitoring/Tracking tools for keeping a picture of all current and past resource exchanges.

The organizational structure of this web communication device has bottom-up potential. Although it could be embedded within future symbiosis facilitation organizations, such a website could be launched now in any locale with an entrepreneurial vision and would serve as a model for others to follow. Information might be accessible only to registered users to ensure privacy protection, legitimacy, and network stability and reliability. It could be maintained originally by the industries and entrepreneurs who develop it, sold off or embedded within the proposed regulatory body similar to NISP, and sub-tailored to the regional exchange network overseeing body.

There are a couple of options in terms of funding such an endeavor. Option one places the service at the federal level, embedded within a national scale regulatory body with regional outposts as described in the following step. In this case, it could have similar funding to that of NISP where taxes on waste disposal and virgin material use supported by adjusted and increasing transport costs. It could also gain revenue from company advertising within the site.

The benefits of this funding scheme is that it is long-term and self-sustaining. Natural limits delineated earlier in this thesis suggest this is a good model. Advertising on a website as a means of revenue generation is a standard procedure. The drawbacks of this funding scheme is its reliance on major changes in current pricing structure regarding waste disposal and transport.

A second funding option could stem from hybrid, public-private partnerships between the national/regional organizational body proposed below and exchange-involved industries looking to increase their public sustainability image.

The benefits of this funding scheme is that is quickly implementable; industries would support this venture due to the increased environmental image of responsibility and learned cost savings of by-product exchange. The drawbacks of this funding scheme lie within the difficulty of directing funding from private based initiatives to a larger, public-good type service. There are also a few options for implementing such a web-based communication tool, not all necessarily applicable to planners but to a much larger audience:

- Research Institutions (~ $85,000/yr. budget based on Triangle J. data collection exercise)
- Private-Start Ups merging web technologies and ecological sustainability
- Self-organized collection of Industries takes initiative

**STEP THREE: Establish National Symbiosis Regulatory/Champion Organization with State and Regional Outposts.**

Inspired by the recently established National Industrial Symbiosis Programme (NISP) in the UK, this organization's purpose would be to facilitate communication and exchange/data collection standards between industries at local, regional, state, and national levels. Organizationally, it is a national/federal scale umbrella with state and regional outposts. (The NISP model expanded to include the intermediary scale of the States in the U.S.) It could become an expansion of existing organizations already concerned with industrial symbiosis such as the United States Business Council for Sustainable Development (USBCSD).[136]

This platform should avoid problems of the PCSD attempts from 10 years ago and learn from them by being much more holistic and thorough in its approach, balance top-down and bottom-up approaches, and contain the following features:

**Standards promotion across various scales:**

- **Materials Accounting and Flow analysis (inter-firm level)**
- Industries understand that they will need to account for their resource use in the near future. Accounting for such resources is already in place at the national scale in the US. Yet, there are varying levels of this resource use analysis across multiple industries. This proposal of

136 http://www.usbcsd.org/byproductsynergy.asp Surprisingly enough, the United States Building Council for Sustainable Development (USBCSD) was the inspiration for the UK's NISP which has far surpassed what we have here in the states.

standardizing resource accounting should examine existing studies and build on top of them.

- **Symbiosis coordinators or "champions" (inter-firm level)**

- Resource exchange facilitator should become a new position within each industry, potentially building off of existing environmental services department/sector within firms.

- **Data-posting and information accessibility (intra-firm level**
- Information on resource use could be made publicly available, thus opening up opportunities for exchange

- **Waste management strategies (regional level)**
- Regulations should be created to divert wastes away from growing landfills, thus encouraging resource re-reuse as an alternative means of disposal. Regulations must also be careful to prevent the "dumping in the backyard" syndrome this could also create.

- **Land-Use, Urban Design, Environmental Engineering, Physical Planning department to deal with everything from conduit infrastructure design to industrial spatial planning and chang**e (described in further detail in the next step)

- **Waste Policy for recycling and re-use (state level)**
- Incentives should be created at the state level for industries that engage in resource re-use practices coupled with other environmental benchmarks such as carbon reduction/offsetting. This could greatly expand the practice of industrial symbiosis in the United States, if coupled with all of the previously mentioned tools.

- **Product design and Material use/development standards (national level)**
- Major reductions in resource use can be attained through design better products that are multi-functional, longer-lived, and re-usable. Regulatory standards requiring this

will increase with time, and could greatly change the way that current industries operate.

**- Intra-firm Communication Facilitation Tool (See Step Two)**

- **Liaison between local industries and state/national governments** responsible for regulations regarding wastes, materials, energy exchange (see the UK's National Industrial Symbiosis Programme (NISP) case study)

**- Raising public awareness and visibility of symbiosis and industrial ecology (see step one)**

- **Encourage behavioral incentives for the incorporation of best practices**
- This could come in the form of economic incentives for adhering to the new regulations proposed above

- **The regulatory body could contain multiple divisions**, including a physical planning component (see below) for understanding the transformation of the current industrial landscape over time

There are several options for funding this organization. (The options are the same as above but copied here for ease of reading).

One option places the service at the federal level. In this case, it could have similar funding to that of NISP where taxes are levied on waste disposal and virgin material use to make resource exchange a more economical option. The regulatory body could also gain revenue from participating company advertising. The benefits of this funding scheme is that it is long-term and self-sustaining. Natural limits delineated earlier in this thesis suggest this is the best model. The drawbacks of this funding scheme lie within its reliance on major changes in current pricing structure regarding waste disposal and transport, thus requiring considerable effort to implement.

A second funding option could stem from hybrid, public-private partnerships between the national/regional organizational body and exchange-involved industries looking to increase public sustainability image (as mentioned in step one). The benefits of this funding scheme is that it is quickly implementable; industries would support this venture due to the increased environmental image of responsibility and learned cost savings of by-product exchange. The drawbacks of this funding scheme would be the difficulties of directing funding from private based initiatives to a larger, public-good type service.

Planners could be a tremendous resource for catalyzing the development of such an organizational structure. For a detailed description of different planner types' contributions, continue onto "the facilitation role of planning".

**STEP FOUR: Plan and Design with Resource Limits, Change, and Adaptability in Mind.**

Physical planning must respond to future trends in energy, resources, mobility, and spatial patterns of industrial development. As such, specialists in physical planning must be embedded within the newly established National Symbiosis Organization (step 3) to anticipate the need for future reformatting and upgrading industrial spatial networks to facilitate resource use minimization and exchange. Strong ties between practice and academic theory must be created through a variety of professional programs aimed at transferring knowledge from real-world implementation experience to an academic setting. Research institutions could form partnerships with industries involved in symbiotic exchanges to analyze performance and develop further technologies to increase resource re-usability. This type of 'real-world /academic symbiosis' would be best fostered by short-term by one year (or even summer-long) workshops and programs for mid-career professionals transferring and sharing their expertise in an academic setting. Most planners are out there in the trenches, with little subjectivity to the industrial ecology discourse. Setting up short-term, professional workshops housed at research institutions could become a means of bridging this knowledge and practice gap.

Longer term pedagogic overhauls should also begin to embed industrial ecology and symbiosis into the planning and architecture curriculum, as evidenced by classes at MIT such as course 4.406, "Ecologies of Construction". Such multi-disciplinary classes are comprised of students from many different backgrounds cooperating to solve the pressing issues of resource and energy use, and they resemble the expanded interdisciplinary model required for tackling the same issues in practice. Teams comprised of chemists, material scientists, urban information systems specialists, environmental engineers, ecologists, landscape architects, and urban designers/planners must communicate from the onset of industrial symbiotic projects. This networked approach emphasizes the role of the planner/designer as transitioning from the sole visionary to the collaborator, who after synthesizing the information and expertise from the aforementioned disciplines is responsible for translating this information into the language of built form.

### *The Facilitation role of Planning*

Much of what planners' advocate (and have been advocating for a long time) coincides with the goals of industrial ecology and would be extremely beneficial for fostering industrial symbiosis. The previous chapter's scenarios delineate changes in the near future. The role of different types of planners in advancing industrial ecology will build on approaches they normally advocate, yet there will be far more momentum for their implementation. Planners should be involved in every step of the process of advancing industrial symbiosis, by continuing objectives in the following areas:

- **Environmental Policy and Planning**
    - Local Level: Promotion of policies on waste management and eradication of exchange-inhibiting regulations
    - Regional Level: Resource management regulation and policy
    - National Level: Promotion of ecological economics, true-cost pricing, ecological footprint, product re-design and life cycle analysis

- **Urban Information Systems**
    - Continued development of geospatial mapping and resource tracking technologies applied to real time energy and resource flows – focus on information quality and accessibility

- **Transportation Planning and Policy**
    - Continued support for dense, multi-modal enabled development patterns
    - Continued mapping and data collection of transport infrastructure usage to better inform potential physical exchanges

- **Physical Planning:** [Urban Design, Landscape Architecture/Ecology, Architecture]
    - Inclusion of symbiosis into Sustainable Standards (LEED) of built-form construction.
    - Industrial Symbiosis/Ecology embedded within architectural/urban design pedagogy:
        - See professional/academic workshops and programs mentioned above. (short term)
        - Hybridize current trends and theories in urban design: ecology and urbanization (landscape urbanism), ecological design, compactness/new urbanism, with energy and resource education as well as restructure curriculum to include interdisciplinary courses focused on collective problem solving of resource and energy futures (longer term)

There is a convergence between the goals of industrial ecology and planners, because planners already advocate much of the tools needed to foster a environment conducive to industrial symbiosis. This convergence will grow in the future, if current trends in resources are to continue as expected, thus creating tremendous opportunities for planners to become effective symbiosis champions.

### *Timescales of interventions*

Each of these interventions will fit within the scenarios described in chapter four, delineated by future trends in energy and resources. Steps one and two, increasing the visibility of symbiotic exchanges and utilizing data, information, and communication tools, respectively, are the least dependent on the timing of resource futures, and could occur now. The symbiosis-facilitating regulatory structure described in step three is somewhat dependent on the timing of resource futures, thus, could begin to be created between now and the next five years. The creation of this regulatory body will depend on how quickly the limits to symbiosis are overcome, catalyzed by future energy and policy trends. The physical planning and reformatting of industrial spatial locations described in step four is the most dependent on the timing of resource futures. As such, retrofits and new spatial arrangements could occur anywhere from within the next 5 years (according to the near-peak scenario listed in chapter four), to the next 25 years (according to the far-peak scenario in chapter four.) The establishment of professional/academic knowledge exchange programs regarding industrial symbiosis should occur as soon as possible to prepare for these future changes in resources and how industries change.

### *Providing the Vision*

An important limit to industrial symbiosis within the United States is a lack of vision for its large scale implementation. It must be re-stated that industrial symbiosis will not occur at a widespread scale within the US without major changes in energy and material costs, which are projected to rise in the near future at a potentially catastrophic rate. The scale of changes in the near future has also create roadblocks to thinking creatively about how industrial symbiosis could become manifest in this country. However, planners and urban designers are well equipped to provide this much-needed vision. Their ability to understand change over time, to effectively allocate scarce resources, and to translate regulatory mechanisms and goals into the physical language of the design of human settlements situates them in prime position to become major champions and guides for the future of industrial symbiosis within the United States.

Coupled with the desires of industries to become more visibly environmentally responsible, industrial symbiosis is one more potent tool within the larger fight against global warming and large-scale environmental degradation. Planners and urban designers can be take on this task now, use the tools above, adapt to the outline strategies, and provide a true vision of sustainable industrial processes in the future.

There are a host of tasks regarding the transformation of the built environment from its current, fossil dependent state to one more responsive to limited energy futures and conducive to industrial symbiosis, of which the tools listed above are means of achieving. This work should begin to be implemented as soon as possible.

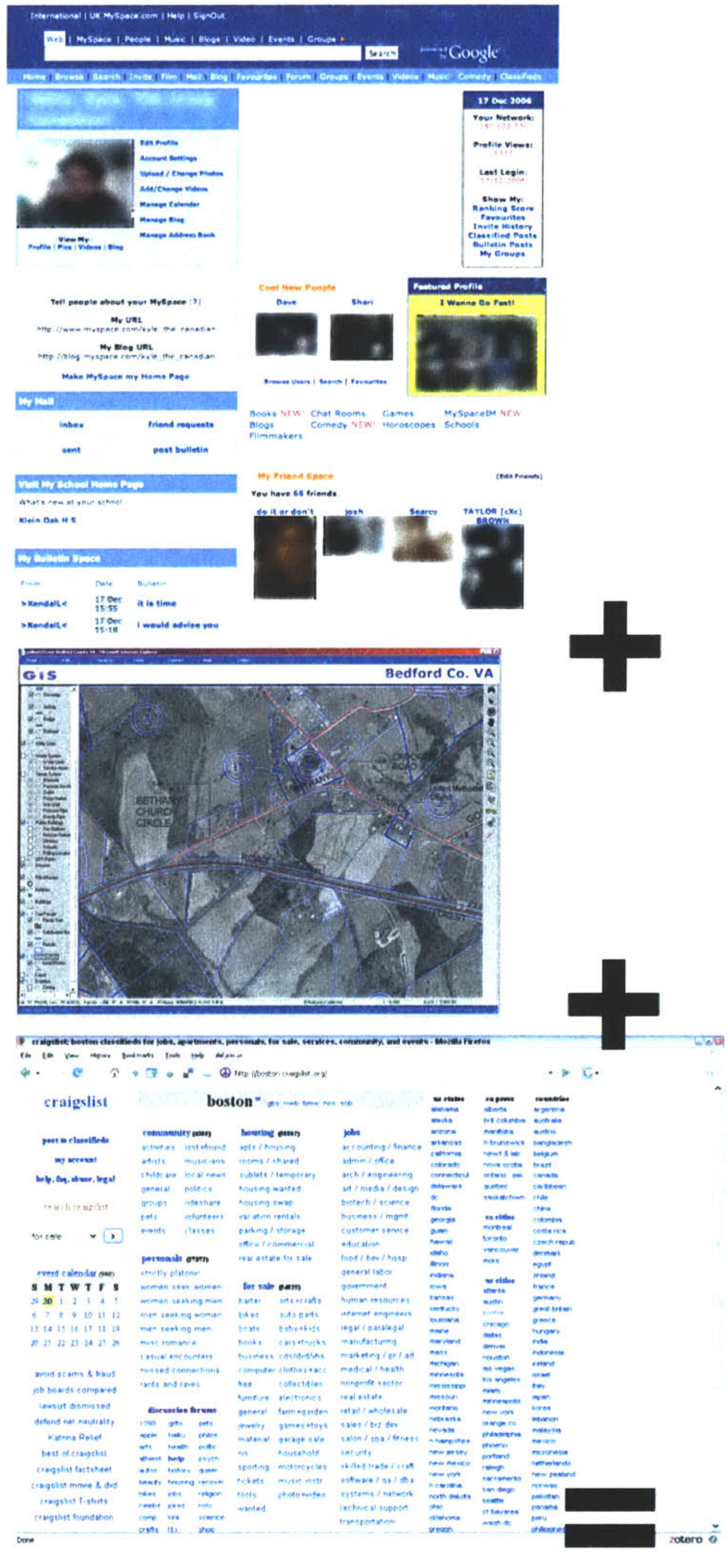


**Figure 57: Step Two - Web-Based communication tool hybridizes existing platforms**

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# Appendices

## PCSD U.S. Eco-Industrial Park Profiles, 1996[1]

A. Summaries

**Fairfield Ecological Industrial Park -- Baltimore, Maryland.** The Fairfield EIP encompasses over 1300 heavy industrial zoned acres and approximately 60 operating companies located in the South Baltimore Empowerment Zone. The site's superior port, rail, and interstate access will be used to maximize the intermodal transit of raw materials and waste streams, which will facilitate the creation of an industrial "closed loop" production process. The Fairfield EIP strives to demonstrate superior environmental and industrial results through: expanding pollution prevention programs; integrating innovative environmental technologies; engaging in creative Brownfields redevelopment; expanding business networks; streamlining State and City permitting processes; and in implementing an extensive master planning and fiscal impact analyses. Moreover, the Baltimore Development Corporation, along with a diverse pool of business, government, academic, union, and community stakeholders, is designing a new regulatory framework through the EPA's Project XL for Communities. Early successes at the EIP include: securing funds and initiating plans for the demolition and site preparation of a vital 30 acre industrial site; initiating a state sponsored pollution prevention mentoring program; "jump starting" Port of Baltimore expansion at Masonville; implementing a land swap and ordinance process; initiating new road and rail construction; and revitalizing a series of abandoned sites through new building and industrial redevelopment projects.

**Brownsville Eco-Industrial Park -- Brownsville, Texas.** The Brownsville project is based on a regional approach to materials exchange that will include connections to small businesses and agriculture. One key element is the design of an industrial al process database to help in identifying potential linkages among existing and potential new companies.

**Riverside Eco-Park -- Burlington, Vermont.** The Riverside Eco-Park is an "ecological-industrial park" whose mission is to demonstrate and promote the commercialization of technologies that effectively utilize indigenous renewable resources that may be transferred to other communities that are interested in sustainable and ecologically sound development. The focus is on biomass energy production integrated with living systems and urban agriculture technologies on the principle of maximizing the utilization of renewable resources to provide electricity and heat applied to living systems that add value to wastes and expand the ability to grow food and flowers locally. Projects integrating biomass energy, living technologies and urban agriculture can be applied to many sites throughout the world to retain existing or to develop new businesses that are challenged with issues of economical energy supply, food production, and waste disposal. Thus, technology transfer will be a very important feature of the Eco-Park.

**Burnside Eco-Industrial Park -- Halifax, Nova Scotia, Canada.** This is a six year multi-disciplinary, multi-institutional action research and education project involving an existing

[1] http://clinton2.nara.gov/PCSD/Publications/Eco_Workshop.html#v Accessed 2 November 2006.

industrial park with cooperative partnerships among academic, government, owners, developers, and tenants.

**Port of Cape Charles Sustainable Technologies Industrial Park -- Cape Charles, Virginia.** Managed by the Joint Industrial Development Authority of Northampton, the Park was designed as part of a comprehensive Sustainable Development Action Strategy y. The EIP will incorporate industrial ecology linkages such as recycled water and by-product exchanges. Solar Building Systems, a manufacturer of photovoltaic panels that convert sunlight to electricity is the first tenant to locate.

**Civano Environmental Technologies Park -- Tucson, Arizona.** An eighty acre commercial-industrial campus located within Civano, a 1,147 acre integrated development in Tucson's east side, is a private/public effort of Case Enterprises and the City of Tucson. The community will be the first major development in North America to unite Sustainable and New-Urban concepts in village planning. Civano will offer 3,000 homes in a full range of housing types and prices, extensive recreation and activities centers, a golf course, and green belts providing scenic pathways from homes to recreation and employment centers. The Environmental Technologies Park, which is planned as a center for sustainable technologies and practices, has begun construction for its first industrial tenant, Global Solar, a photo-voltaic cell manufacturer. All buildings in the park will be built to exacting "green" construction standards. Other firms currently in negotiation for relocation into the park include manufacturers of electric cars, wastewater/water purification systems, and passive solar water heaters.

**Chattanooga, Tennessee -- The Volunteer Site.** The site is 7,000 acres of land that was formerly a TNT manufacturing plant. Individual sites of up to 2,000 acres are available for use. ICI Americas Inc. has managed the site since 1953 and is interested in developing an eco-industrial park on the site. Targeted partners include warehouse/distribution companies, heavy and light manufacturers, companies that focus on environmental services, and other industries that re-manufacture and re-use existing products. The overall goal is to create over 10,000 jobs at the site by the year 2020 and create economic benefits by opening access through the plant and allowing local governments to use the facilities to provide services. ICI Americas is using the "clusters" approach to identify businesses that could share wastes as a way to attract and select tenants for the site. They have created a Business Development Center to assist in the recruitment of new businesses and plan to develop utility cost data to demonstrate how the eco-industrial park concept is cost competitive with other locations.

**East Shore Eco-Industrial Park -- Oakland, California.** The anchor for this EIP will be a resource recovery cluster encompassing reuse, recycling, remanufacturing, and composting companies. With this foundation, recruitment will target other tenants manufacturing from recycled feedstocks and renewable materials; firms making renewable energy equipment and systems; and environmental services ventures. The multi-county Economic Development Alliance for Business is sponsoring a project feasibility study to start in early 1997.

**Green Institute Eco-Industrial Park -- Minneapolis, Minnesota.** This small EIP is undertaking a baseline study of more than 600 industrial companies in the vicinity of its 3.5 acre site. The baseline study will be used to promote material and energy y exchanges among these existing companies and to focus the tenant recruitment and business development efforts of the Green Institute's incubator program. The Green Institute project is also unique as a grassroots, neighborhood effort that incorporates environmental education and youth participation into many aspects of its programs.

**Plattsburgh Eco-Industrial Park -- Plattsburgh, New York.** With the assistance of Cornell University and U.S. Facilities Management, Inc., the Plattsburgh Airbase Redevelopment Corporation is designing an EIP for the 3500 acres of the decommissioned d Air Force facility.

The project emphasizes continuous improvement in economic and environmental performance through resource sharing, by-product exchanges, and an environmental management system conforming to ISO 14001. Elements of the EIP will include de new development by manufacturers and transportation firms; ecological, cultural, and heritage tourism; environmental technologies; biomass generators; multi-modal distribution; and several "environmental enhancements" connected to the regional eco-sys tem between Adirondack Park and Lake Champlain.

**Raymond Green Eco-Industrial Park -- Raymond, Washington.** The Raymond Green Industrial Park will be developed within a second growth coastal forest that will continue to be selectively harvested. The site encompasses the entire upper drainage bas in of Butte Creek, thus the water quality within the site can be uniquely managed. Targeted firms include those that can make use of local natural resources and have low impact manufacturing processes.

**Skagit County Environmental Industrial Park -- Skagit County, Washington.** In the Fall of 1995, a feasibility study for the EIP was completed that identified potential sites, potential tenants, the projects economic prospects, and components of the e EIP. It is expected that the park will include a recovery center built with energy efficient recycled content materials, manufacturing center, a community building, sales and marketing space, environmental businesses, and a closed loop system with mini mal effluent and emissions.

**Shady Side Eco-Business Park -- Shady Side, Maryland.** Key features for this park include the renovation of an existing facility in an underemployed and under served community; integration of successful community-based tools and approaches; and the demonstration of Business Ecology Round tables. The Round tables are an innovative series of workshops and tools designed to help business and community leaders integrate economic, social and environmental goals. Possible tenants include a micro brewer y, fish and shellfish aquaculture, marine exploration and technology, oil recycling, water reclamation, solar and renewable energy, and composting.

**Stonyfield / Londonderry Eco-Industrial Park -- Londonderry, New Hampshire.** Planners for the park are interested in using covenants to assure that industrial ecology is the model for future development. Using community and business input, Stonyfield Farms Inc. and the Town of Londonderry are working to develop the project.

**Trenton Eco-Industrial Complex -- Trenton, New Jersey.** Trenton's EIP will not necessarily be a physical place, but likely a network of businesses with numerous opportunities for linkages. The Eco-Industrial Roundtable - a multi stakeholder steering committee guides the activities of the project. Cornell University is conducting a baseline assessment to determine possible linkages between existing and future businesses.

**B. Detailed Descriptions**

Prior to the workshop, each community was asked to prepare responses to the following questions:

- What are your EIP's key features?
- What constitutes success?
- What are your EIP's linkages?
- What is your recruiting process?
- What resources do you have available?
- What is your strategy to continue progressing?
- What is missing?
- What are your goals for the upcoming workshop?

Their responses follow.

**1. FAIRFIELD ECOLOGICAL INDUSTRIAL PARK**

Baltimore, MD
Address: 36 S. Charles Street 16th Floor, Baltimore, MD 21201
Managing Entity: Baltimore Development Corporation
Contact Person' s Name: Michael J. Palumbo
Phone: (410) 837-9310 ext. 341
Fax: (410) 837-6363
E-mail: MJPIII@aol.com
Alternate Contact Person: Larisa Salamacha
Phone: (410) 837-9310 ext. 340
Fax: (410) 837-6363
E-mail: N/A

**EIP's key features.**

- More than 1300 acres zoned for heavy industrial development. Approximately 60 businesses already operate within the ecological industrial park's primary boundary.
- Represents the only Empowerment Zone City grantee with a designed ecological industrial park.
- Pursuing a process to redefine the area's regulatory framework through EPA Project XL for Communities.
- Inter-modal transportation opportunities and mass transit commuting options which are intimately tied to economy redevelopment.
- Establishing business information networks within the park to expand collaborative efforts and material reuse opportunities.
- Playing a more active role in identifying industry education and training skill requirements and in establishing or coordinating linkages with training providers.
- Provides the State of Maryland to model a new voluntary compliance approach to Brownfields redevelopment.
- Completing a master planning exercise which will produce site ownership and environmental quality matrices, electric and natural gas line grids, inter-modal transportation and commuter alternatives, and infrastructure suggestions and priorities tied t o promoting sustainable business practices.

**What constitutes success?**

- Demonstrate that environmentally motivated business networking leads to greater productive efficiency by lowering direct and indirect operational costs, while improving the cross-media environmental conditions of the site
- Preserve critical areas and decrease cross-media emissions and environmental impacts, improving the quality of living for neighboring residents.
- Create 2500 new jobs with above average wage scales over the next 5-10 years.

**EIP linkages.**

Hold multi-stakeholder contact and conferences, for example, to consider detailed input/output information for consideration in a material reuse exchange. Explore connections to targeted waste exchanges and to recruit potential environmentally technology y oriented firms which may be able to use the existing waste streams and/or provides the raw material feedstock. We also are exploring the possibility of joint treatment facilities to improve the economics of scale related to these types of investments.

**Recruiting process.**

The recruitment and redevelopment strategy for Fairfield provides a unique focus and allows for considerably more opportunities to leverage State and Federal funds than more traditional development approaches. In addition to the obvious benefits associated ed with the

Empowerment Zone, The Ecological Industrial Park targets its recruitment toward three specific company types. As a complement to the recruitment plan, BDC also had instituted an active existing business expansion and infrastructure improvement t program. It is this combination of approaches that truly delineates the Eco-Industrial Park concept. The types of businesses being recruited or targeted for expansion include:

- Clean Manufacturing or Commercial Uses Which Practice Environmental Responsibility and Leadership: 1-3 significant size companies (350-500 employees) to expand the industrial/ commercial base of the area.
- Environmental Technology Providers: 8-10 environmental technology providers (50-100) employees) to expand the pollution prevention, business networking, and closed loop capabilities associated with the Eco-park.
- "The Multipliers" or Service and Other Environmental/Recycling Companies: 10+ small service oriented company's (10-50 employees) to fill in strategic needs created by the increased markets and demand generated through the Business expansion.
- Expanding Existing Employers: improve the regulatory environmental and operational conditions to help stimulate business expansion of existing firms, especially among those firms which possess excess property.

**Resources available.**

We currently receive direct funding through the Empower Baltimore Management Corporation which distributes funds from the HUD Empowerment Zone Grant. The Fairfield EIP also received funds through the Baltimore Development Corporation. Outstanding funding g proposals for specific activities outlined in the EIP Strategic Plan have been or will soon be submitted to the Economic Development Administration, the Environmental Protection Agency, and Maryland Department of Economic and Business Development, the Maryland Department of the Environment, and the Department of Energy. In addition, private funding is being pursued through local and national lending institutions, social investment and venture capital funds, local foundations, and EIP membership obligations.

**Strategy to continue progressing.**

Our comprehensive redevelopment strategy is illustrated by the attached exhibit.

**What is missing?**

Assistance is needed in the following areas:

- Secure and reliable site assessment information and support for Phase I site assessments.
- Information related to cost or efficiency improvements associated with environmental technology or pollution prevention integration.
- Creating significant and meaningful incentives to motivate firms to operate in a manner that would stimulate sustainable practice, i.e. market driven advantages for "green" or environmentally conscious manufacturing processes and products such as "preferable products" designation or public sector purchasing targets.
- Provide technical assistance or funding that would support the integration of pollution prevention, environmental technology, and material reuse integration, i.e. detailed input/output analyses which expose innovative ways to reuse resources.
- Provide collective waste water treatment, energy co-generation, and emission reduction models or strategies, analyses, or information.
- Provide funding for the creation of an eco-manufacturing research facility including education and training provisions to prepare workers for new occupational growth in environmental industries.

**Goals for the upcoming workshop.**

- To share ideas about conducting a wide variety of support activities which promote business expansion, job creation, and community redevelopment, while implementing the characteristics of an ecological industrial park.
- To share ideas and successes to demonstrate that economic growth can occur without having a greater negative impact on the environment.
- To build partnerships to ensure that the ecological industrial park concept becomes a traditional way of doing business in the 21st century.

**2. BROWNSVILLE ECO-INDUSTRIAL PARK**

Brownsville, TX

Address: 1205 N. Expressway, Brownsville, TX 78520

Managing Entity: Brownsville Economic Development Council

Contact Person' Name: Rick Luna, Director of Communications/Research

Phone: (210) 541-1183

Fax: (210) 546-3938

E-Mail: broedc@aol.com

Alternate Contact Person: Jackie Lockett, Brownsville Information & Solutions Network

Phone: (210) 546-1161

Fax: (210) 982-1876

E-Mail: bisn@triplesoft.com

**EIP's key features:**

The Brownsville project is based on a regional approach to materials exchange (regional "industrial symbiosis" (IS). Establishment of a defined "eco-industrial park" is considered as one possible component of regional IS, but not the driving force. Brownsville IS also is inclusive of small businesses and agriculture.

**What constitutes success?**

Project will yield an industrial IS "road map" identifying opportunities to increase the operating efficiencies of existing industries and opportunities for recruitment of new industry in the Brownsville region.

**EIP linkages:**

We have developed an industrial process data base both of companies existing in Brownsville and Matamoras, Mexico and in industries elsewhere in the U.S. Our consultant has developed analytical procedures to identify potential materials exchange linkages among these industries for both existing and new companies.

**Recruiting process:**

Planning tools developed for the Brownsville project identify potential firms likely to benefit from participation in regional industrial symbiosis. Tools also quantify and value materials for exchanges. Then potential firms, new or existing, are contacted d to discuss opportunities for cost savings.

**Resources available?**

U.S. Department of Commerce

Brownsville Economic Development Council

City of Brownsville, Port of Brownsville

**Strategy to continue progressing.**

1. Cost data need to be added to materials flow data base (consultant)
2. Marketing plan is to be developed for strategy to evaluate and contact IS participants (BEDC)

**What is missing?**

1. Additional process detail (input, output, utilities flows will increase rigor of planning tools)
2. Cost data are yet to be developed
3. A more efficient method of identifying "new" industry opportunities will speed process

**Goals for the upcoming workshop.**

1. Brief other projects on status of Brownsville project.
2. Demonstration of uniqueness of our approach.

**3. RIVERSIDE ECO-PARK**

Burlington, VT
Address: The Intervale, Burlington, VT 05401
Managing Entity: Burlington Electric Department (interim)
Contact Person' s Name: Steve Burroughs, General Manager
Phone: (802) 865-7406
Fax: (802) 865-7400
E-mail: gmatbed @ aol.com
Alternate Contact Person: Robert Skiff
Phone: (802) 656-3833
Fax: (802) 656-8678
E-mail: N/A

**EIP's key features.**

The Riverside Eco-Park is an Agricultural-Industrial Park in an Urban setting. Its focus is two-fold:

- Bio-Energy - green electricity generated using bio-mass fuels
- Living System - living machines, which capture available thermal energy for commercial greenhouse production of fish, organic vegetables, and water purification.

**What constitutes success?**

Success will be the integration of these two existing but separate emerging technologies systems into one closed loop demonstration project which is transferable to the communities.

Measurements for a positive outcome are qualitative and quantitative

- reduced dispersion of generating station "waste" heat into the air and water
- improved environmental condition - soil and water quality, recycling volume increases
- increased self-sufficiency for the community in percent of food produced locally
- creation of sustainable jobs and training programs appropriate to our region
- increase of recreational and educational opportunities for area residents

**EIP linkages.**

The two emerging technology systems of bio-energy and living systems have been analyzed for compatibility through the process of a feasibility study. This study took input and outflow data from both systems, as well as current procurement practices and waste dispersion, and matched them to achieve theoretical improvement in efficiencies for both systems, joined in closed-loop.

Our next step will be the schematic engineering and cost analyses of this system, followed by an urban farm demonstration project to test and fine-tune viability.

**Recruiting process.**

Our EIP has identified an unique geographic area, and established its existing natural and economic resource strengths. The McNeil Generating Station, Living Technologies, Gardener's Supply Company, and the Intervale Foundation are located on a fertile tract of 680 acres of underutilized urban agricultural land. Additional companies will be added or recruited as the patterns, strengths, and weaknesses of the first demonstration project unfold.

Our ultimate hope is to take our two base systems of bio-energy and living systems from research and development, through commercialization, to spin-off industry creation at this site. The creative products of this process will then be fed back to our eco-park structure for expansion, as well as to other sites, and the creation of other eco-industrial structures.

**Resources available.**

Sources for funding to date for our feasibility study are:

- Community development Block Grant - $9500
- Burlington Electric Department - $9800
- Department of Public Works - $5000
- In-kind contributions for
  - GIS CADD data base drawings and planning
  - Waste heat data analysis
  - Project administration

Applications have been made to EPA and DOE for Phase 2 funding.

**Strategy to continue progressing.**

A multi-agency collaborative approach to funding and support is critical and sensible. We are working with the Department of Energy to design a process for federal agencies to cooperate on projects such as ours that cross the lines of Departments of Energy, Commerce, EPA, and USDA or others as examples.

**What is missing?**

Information and tools that would help us implement our plans might include:

- Planning and zoning strategies for low-impact industries
- Funding sources for EIP planning and implementation
- Research and development data on EIP systems already in place
- Case studies on existing EIPs
- Interagency cooperation - a central clearinghouse approach to information and resources

**Goals for the upcoming workshop.**

We are hoping to get a one-stop comprehensive snapshot of EIP development in the country, to evaluate and improve our own approach, and to share our best and most successful ideas with others. This should be an excellent forum, and may result in good idea as to continue the momentum of information exchange after October 18th.

**4. BURNSIDE ECO INDUSTRIAL PARK**

Halifax, Nova Scotia, Canada

Address: 1312 Robie Street, Halifax, Nova Scotia B3H3E2

Managing Entity: Burnside Industrial Park as Ecosystem

Contract Person's Name: Raymond Cote

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Fax: (902) 494-3728

E-Mail: N/A

Alternate Contact Person: W. Wayne Barchard

Phone: (902) 426-4695

Fax: N/A

E-Mail: N/A

**EIPs Key features.**

Burnside Project

- 6 year multi-disciplinary, multi-institutional study of requirements;
- cooperative partnership among academics, 3 levels of government, owners, developers and tenants;

- phases/retrofitting and planning;
- innumerable, constantly changing SMEs.

**What constitutes success?**

- Commitment from park owners;
- Flexibility in implementation of Environmental regulations;
- Participation by capital owners;
- Appropriate economic instruments;
- Active information, education and interpretation; and
- A technical extension service.

**EIP linkages.**

- System Definition [Surveys and database]; Industrial, social, brainpower inventories
- Food Web [Materials Flow Database];
- Energy Conservation [Energy Audits];
- Resource Conservation [Waste Audits, and Materials Exchange];
- Scavengers and Decomposers [Recyclers and Waste Managers];
- Information Exchange [Cleaner Production Centre Business Leaders Forum, Newspaper Column].

**Recruiting process.**

(Not yet developed)

**Resources available.**

- Federal-Provincial Sustainable Development Fund;
- The Donner Foundation;
- Halifax Regional Municipality; and
- Federal and Provincial Governments three Academic Institution

**Strategy to continue progressing.**

- United Nation Environmental Program-Industrial Estate Guideline;
- Work with the new HRM Industrial Development Commission;
- Revision of the Regulatory Structure (Sewer Bylaw, Solid Waste Strategy, Provincial and Federal Acts);
- Federal and Provincial Pollution Prevention Strategies;
- Newest Phases of Burnside using some of the Design Criteria; and
- Continuation of Leader's Forum, regular Newspaper columns.

**What is missing?**

- Firm commitment by the owners, builders and capital managers;
- A supportive Regulatory Structure; and
- Stable funding for the Extension Program.

**Goals for the upcoming workshop.**

**5. PORT OF CAPE CHARLES SUSTAINABLE TECHNOLOGIES INDUSTRIAL PARK**

Eastville, VA

Address: P.O. Box 530, Eastville, VA 23347

Managing Entity: Joint Industrial Development Authority of Northampton

Contact Person's Name: Timothy Hayes

Phone: (757) 678-0477

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E-Mail: northampton@esva.net

Alternate Contact Person: Thomas Harris

Phone: (757) 678-0440

Fax: (757) 678-0483
E-Mail: northampton@esva.net

**EIPs Key features.**

- Provides the infrastructure for industrial ecology linkages among companies.
- Improves the economic, natural, cultural, and social and living environment of the site and the surrounding region.
- Designed by the community as part of a comprehensive Sustainable Development Action Strategy with mixed use, and a nature preserve.
- Zero Emissions Design.

**What constitutes success?**

- Private for-profit investment in new companies and expansion of existing companies in the Park.
- Jobs created for local people.
- Employee-owned companies created by local people.
- Natural and cultural resources protected and maintained.

**EIP linkages.**

- Providing for water recycling within the Park through a used water collection system, water recovery facility and recycled water distribution system.
- Plan to form a technical panel to analyze by-products of existing and proposed companies for potential use by other existing, and proposed companies.
- Mixed residential, commercial, industrial uses.

**Recruiting process.**

- Providing the infrastructure necessary for companies to operate successfully - product.
- Providing land, utilities, services, amenities at competitive rates - price.
- Part of National Historic District - Town of Cape Charles.
- Surrounding town and county maintaining its spectacular natural, historic and living environment - place.
- Strategic alliance with Eastern Shore Economic Development Commission and Virginia Economic Development Partnership - promotion.

**Resources available.**

- Local - Northampton County and Town of Cape Charles purchasing and providing land and partial design funds.
- Region - Easton Shore Resource Conservation and Development providing partial construction funding.
- State - Virginia Coastal Program, Development of Transportation, Department of Conservation and Recreation providing partial design and construction funding; Virginia Department of Housing and Community Development.
- Federal - U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Economic Development Administration, U.S. Department of Agriculture, U.S. Department of Interior, U.S. Fish and Wildlife Service and U.S. Environmental Protection Agency.

**Strategy to continue progressing.**

- Project managed by County Department of Sustainable Economic Development/Joint Industrial Development Authority.
- Covenants to be established based on master plan and design and operation standards.
- Recruitment process focusing on industrial ecology components to be developed and implemented.

**What is missing?**

- How to establish an effective process for developing, facilitating, managing an industrial eco-system.
- In conjunction with above, establishment of an effective marketing/recruitment program.
- Construction of Flex/Incubator space for lease to small/medium size companies within the park.

**Goals for the upcoming workshop.**

- Start of an ongoing network of EIP developers/operators.
- Find out how other EIP's are achieving success and overcoming similar challenges as we are.
- Identification of potential additional funding/investment sources.

**6. CIVANO INDUSTRIAL ECO-PARK**

Tucson, AZ

Address: 6280 S Campbell Avenue, Tucson, AZ 85706

Managing Entity: Community of Civano LLC

Contract Person's Name: David Case

Phone: (520) 889-8888

Fax: (520) 889-6207

E-Mail: casent@primenet.com

Alternate Contact Person: John Laswick

Phone: (520) 791-5093

Fax: (520) 791-5413

E-Mail: N/A

**EIPs Key features.**

The Civano business park is part of an integrated development that emphasizes human interaction and environmental responsibility. The businesses that are being sought will enable the Civano business park to become a center of sustainable technologies and practices. Civano will become more like an EIP as it becomes more like a "virtual corporation" where businesses with certain core capabilities (e.g., makers of PVs, electric vehicles, circuit boards, steel fabricators, design firms, renewable construction, etc.) come to coordinate their activities, share resources, and participate in joint operations, such as water treatment, and reduce dependence on transportation and increase competitiveness.

**What constitutes success?**

The current aim is to attract companies that fit into the general concept of a sustainable community. At present, the chief measure of success, besides simply being a viable business district, is to succeed in attracting critical "flagship" companies that t both set the philosophical tone for the business development thru the use and production of renewable resource technologies and also promote the idea of a business park that is center for sustainable technologies.

**EIP linkages.**

Prior to the purchase of the Civano land by the current developer, the City of Tucson organized two major workshops on business development at Civano. These brought together business, financial, academic, and other organizations that are interested in the e idea of a business district with distinctive characteristics. The Metropolitan Energy Commission, which originated Civano, and the City have developed new resource-efficient building codes and builder training programs for Civano which will be used to promote sustainable technologies and will likely form part of the economic incentive for certain types of businesses. The local and state economic development agencies are including Civano in their recruitment and expansion programs.

**Recruiting process.**

In addition to including Civano in the recruitment programs of the Greater Tucson Economic Council, a Civano Institute is being created to conduct training programs for local builders in the Civano building techniques and to promote the concept of sustain able building technologies throughout the community. Other agencies, such as a new university and the local community college have campuses in the area and both have sustainable technologies programs. Both have expressed an interest in working with Civano.

**Resources available.**

Original funding for developing the Civano concept came from a $600,000 grant/loan from the State of Arizona Department of Commerce. These funds were repaid when the current developer purchased the Civano property from the State. Of course, the developer r is organizing aggressive marketing and recruitment campaigns. In addition, many thousands of hours of volunteer time have been contributed for at least 10 years to develop the concept of Civano and bring it to the current state.

**Strategy to continue progressing.**

Civano is an integrated residential development with an important business component. In that context, some of the key pieces include the development of a marketing plan, identifying and signing leases with "flagship" companies, and the implementation of the Civano Institute and the Civano builder program.

**What is missing?**

Chiefly, examples of EIPs that will show how to develop a marketing plan and infrastructure plan that will make Civano an attractive business property, without "breaking the budget." We need a better understanding of the characteristics of EIPs that provide competitive advantages over traditional business developments.

**Goals for the upcoming workshop.**

Understanding and examples.

**7. THE VOLUNTEER SITE**

Chattanooga, TN

Address: 6703 Bonny Oaks Drive (mail: P.O. Box 22608)

Managing Entity: ICI Americas, Inc.

Contact Person' s Name: Charles "Sid " Saunders

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FAX: (423) 855-7270

E-mail: N/A

Alternate Contact Person: T.R. AndrakeMatt

Phone: (423) 855-7252

Fax: (423) 855-7270

E-mail: N/A

**EIP's key features.**

- 7,000 acre parcel of land interlaced with utilities and transportation infrastructure.
- Individual sites of up to 2,000 acres are available for commercial use.
- A business development center to help establish new businesses.
- A national environmental test center to develop environmental technologies are on site.
- Civilian organizations can use facilities, land equipment of this standby U.S. Army Ammunition Plant to produce their own services and products.

**What constitutes success?**

- If we are able to create 10,000 jobs at the site by year 2020.

- Establish cooperative arrangements with local governments to use the facilities to provide services.
- If the Volunteer Site can become a model for converting National military assets to the civilian sector.
- Maintain capabilities for the Volunteer Site at no cost to the Army.

**EIP linkages.**

- The Volunteer Site is using the "cluster" approach to target specific industries.
- Provide a National Environmental technology demonstration center to perform research, testing and evaluation.
- Establish an academic center of excellence for sustainable development and environmental management.
- "Phased development" is being implemented with parcels of land allocated to each phase. The 650 acre "Brownfield" site is being commercialized first.

**Recruiting process.**

- Using the "Center" industry approach where industries can share common utilities.
- Utilize the U.S. Army's strategic environment research and development environmental test site at Volunteer to recruit new and emerging environmental technology businesses.

**Resources available.**

Under the Congressionally funded Armament Retooling Manufacturing Support (ARMS) initiative, over $100 million has been expended since 1993 to facilitate implementation of the facilities - use strategy, over $10 million of these ARMS funds are scheduled f or use at the Volunteer Site in 1996.

**Strategy to continue progressing.**

- Increase the Business Development Center activities to assist in recruitment and establishment of new businesses.
- Develop utility cost data and identify ways to be cost competitive with other locations.

**What is missing?**

- Information/models to assist in identifying "cluster" industries as prospective tenants for the Volunteer Site.
- Sources of financing to assist new business start-ups comings to the site.

**Goals for the upcoming workshop.**

- Share information about the Volunteer EIP site.
- Learn about the activities at other EIP's.
- Establish contacts with parties that can help the Volunteer Site reach projected goals.

**8. EAST SHORE ECO-INDUSTRIAL PARK**

Oakland, CA

Address: 6423 Oakwood Dr., Oakland, CA 94611

Managing Entity: Indigo Development and Urban Ore

Contact Person' s Name: Ernest A. Lowe (Indigo)

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Alternate Contact Person: Dan Knapp (Urban Ore)

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Fax: (510) 235-0198

E-mail: N/A

**EIP's key features.**

- The anchor for this EIP will be a resource recovery facility encompassing reuse, recycling, remanufacturing, and composting. (We have five companies now looking to move and expand their operations.)
- Our recruitment strategy will build from this base to include other companies including plants in the park's vicinity, whose participants and energy inputs or outputs will help build a web of by-product exchange. Other potential recruits will be in areas of new renewable materials and energy manufacturing.
- The project will demonstrate the potential for reindustrialization based on emerging trends toward a resource efficient and renewable energy and materials economy.
- Site selection and planning will emphasize ecological values in balance with economic issues. The site will be "landscaped" to reflect native ecosystem characteristics.
- Design of the park infrastructure and buildings will emphasize energy efficiency, use of renewable energy and material, and pollution prevention.

**What constitutes success?**

- Traditional economic development and financial values will be met in balance with ecological values.
- Park performance objectives will reflect this balance and insure continuous improvement.
- Community support for the project will be strong because it will provide jobs for those who need them in industry that safeguards their environment.

**EIP linkages.**

- The by-product exchange network strategy will be implemented through a survey of potential recruits, surveys of neighboring businesses, study of county waste stream reports, and workshops with potential recruits. In addition a business incubator will be set up to support development of new businesses to fill niches in the exchange.

**Recruiting process.**

- A coalition of the Recycling Market Development Zone, the Alameda County Waste Management Authority and Recycling Board, and local and state economic development agencies has already been established.
- The business incubator and entrepreneurial support network will support development of successful new firms for the park.

**Resources available.**

Initial organization has been supported by in-kind contribution of the Economic Development Advisory Board. We are seeking Economic Development Administration and/or local foundation funds for site selection and feasibility studies. Our intention is to do the actual real estate development through private investment.

**Strategy to continue progressing.**

- Basically we will use standard real estate development management strategies, while tracking all of the environmental/ecological issues involved.
- FIWP funding for feasibility study.
- Evaluation and selection of sites. Environmental impact assessment.
- Move quickly enough to meet the needs of the resource recovery firms planning expansion.

**What is missing?**

An adaptation of standard development pro formals to reflect values like life cycle costing of alternative park and building infrastructure options that may cost more initially but yield major savings over the lifetime of the facility. And to back that u p, lenders and investors need encouragement to recognize this more systemic financial analysis.

**Goals for the upcoming workshop.**

Better understanding of how other projects are addressing EIP development, what they're learning, how they define their projects.

**9. GREEN INSTITUTE ECO-INDUSTRIAL PARK**

Minneapolis, MN
Address: 433 E. Franklin Avenue, Suite 7A, Minneapolis, MN 55404
Managing Entity: Green Institute
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E-mail: N/A
Alternate Contact Person: Annie Young
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E-mail: young@freenet.msp.mn.us

**EIP's key features.**

This project was not initiated by a government agency or institution of higher learning, but by a grassroots, neighborhood effort. It is unique in its attempt to develop an EIP on a small site of just 3.5 acres by integrating existing businesses into the project. The project is also unique in its commitment to incorporate environmental education into all aspects of the project.

**What constitutes success?**

The Green Institute is employing the EIP and green business incubator and a sector strategy to create 200 living wage jobs. We will measure success by the number of jobs created and by the ability of people from the Phillips neighborhood, the poorest and most diverse neighborhood in Minnesota, to get and keep those jobs.

**EIP linkages.**

We are designing a baseline study this fall with implementation to follow in early 1997. The study is being designed by Green Institute staff and a student/faculty team at the University of Minnesota. The baseline study will look at existing core and secondary businesses within the vicinity of the proposed EIP and analyze raw material uses and waste generation as well as basic economic data. The study is expected to identify opportunities for material reduction, reuse and exchange with other businesses . It will also focus the tenants' recruitment and business development efforts of the project by identifying gaps in closed potential loop business cycles.

**Recruiting process.**

The Green Institute is drafting criteria for tenants in the industrial park and has established a business development program targeted at "green businesses." The main strategy for integrating existing businesses into EIP is through the baseline study de scribed above and existing programs such as the Materials Exchange (MAX) program, and the Minnesota Technical Assistance Project (MATAP) . Tenant recruitment is part of the work responsibilities of a Business Development Specialist staff position. In addition, signage on the proposed site and earned media have generated a substantial number of inquiries from firms engaged in environmental industries.

**Resources available.**

- The Green Institute EIP has received funding through the Federal Enterprise Community program and the local Neighborhood Revitalization Program. The project has also been supported by foundations, including the Minneapolis Foundation and the Northwest t Area Foundation. Construction costs for the EIP are estimated at $6 million of which about $1 million has been identified from government and foundation sources.

- About $2 million will be financed as debt on the project leaving $3 million to be raised as part of a capital campaign in 1997.

**Strategy to continue progressing.**

A detailed work plan and time line are being developed for the staff and board in 1997. The critical next steps include: 1) contract for services with the architectural team recently selected; 2) design and implementation of the baseline study; 3) initiate and implement a capital fundraising campaign; and 4) establish a business development program and build staff capacity.

**What is missing?**

- Models of tenant mixes that would constitute an eco-industrial park of various sizes from a few acres to thousands of acres.
- Strategies for overcoming concerns about proprietary information and regulatory burdens when analyzing the material inputs and waste generation of private businesses.
- Market analyses of the potential for optimal tenants within a given geographic area.

**Goals for the upcoming workshop.**

Establish contacts with other EIPs and learn about other strategies and obstacles to development. Identify capital sources and other resources that can assist in development. Answer some detailed questions with some one-on-one meetings with key EIP participants.

**10. PLATTSBURGH ECO-INDUSTRIAL PARK**

Plattsburgh, NY

Address: 426 U.S. Oval, Suite 1000, Plattsburgh, NY 12903

Managing Entity: Plattsburgh Airbase Redevelopment Corporation

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E-mail: N/A

Alternate Contact Person: R. Bruce Steadman

Phone: (518) 566-6210

Fax: (518) 561-2422

E-mail: N/A

**EIP's key features.**

- Inter-modal/multi-modal capabilities including air, rail, highway, water.
- Former Air Force Base on Lake Champlain.
- ISO 14000/EMS Umbrella Program.
- 3500 contiguous areas with research, commercial, recreational, and industrial facilities.
- Emphasis on resource and waste management and sustainability.
- Proximity to Canadian Border and 1-hour to Montreal.
- Emphasis on lowered environmental cost and improved environmental performance.

**What constitutes success?**

- Achieving the Environmental and Economic goals stated in our plan.
- Becoming the first multi-modal EIP with ISO 14000/EMS Programs in U.S.
- Attraction of Global Companies using our EIP to redistribute goods, set-up a Manufacturing operation, or use regional resources for R&D.
- Successful linking of our Regional Resources into innovative R&D opportunities

**EIP linkages.**

- Input/output analysis of Regional Economy/Resources.
- Stakeholder interviews and focus groups to foster creative thinking.
- Facilitating Partnerships and Joint Ventures between Regional Resources.
- Marrying Economic and Environmental Goals at the beginning of Redevelopment.

- Emphasizing continuous improvement in achieving Economic and Environmental Goals.

**Recruiting process.**

- Inputs/outputs of Region being marketed to users/providers from outside Region.
- Emphasizing Region's commitment to quality by adopting an EIP with ISO 14000/EMS Programs to lower environmental cost and improve performance.
- Facilitating communication between Regional Resources to identify leads opportunities, partnering opportunities and projects.

**Resources available.**

- EPA Region I has financed Phase I of Action Plan with $70,000.
- Opportunities for NY State Environmental Bond Act $$ and Federal $$ are being pursued.
- Regional Resources are being pursued through public outreach programs.
- PARC has committed in-kind resources to help in establishing our goals.

**Strategy to continue progressing.**

- Completion of Phase I Baseline Study.
- Completion of concurrent marketing plan to attract prospects
- Establishment as # 1 US EIP based on location, infrastructure, action plan, commitment, activities, management team, and progress.
- Location of implementation funds for Phase III ( see our strategic plan).

**What is missing?**

- Expanded public outreach and stakeholder involvement in generating leads for prospects, innovative ideas, partnering opportunities.
- Model EMS program based on ISO 14000 to lower environmental costs and improve performance, EPA and NY SDEC and Air force must buy into this EMS to help attract prospects.

**Goals for the upcoming workshop.**

- Networking with Federal and PCSD officials, who may provide support, input, and implementation funding.
- Exposure to prospects will find the multi-model, ISO 14000, Northeast EIP attractive for business (costs down/profits up) and environmental reasons.

**11. RAYMOND GREEN ECO- INDUSTRIAL PARK**

Raymond, WA

Address: 230 Second Street, Raymond, WA

Managing Entity: City of Raymond

Contract Person's Name: Rebecca Chaffee

Phone: (260) 942-3451

Fax: (360) 942-5616

E-Mail: N/A

Alternate Contact Person: Jim Neva

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Fax: (360) 942-5865

E-Mail: N/A

**EIPs Key features.**

The Raymond Green Industrial Park will be developed within a second growth coastal forest that will continue to be selectively harvested. The site encompasses the entire upper drainage basin of Butte Creek. Thus, the water quality within the site can be uniquely managed. The park will not be linked to traditional offsite wastewater and solid waste infrastructure systems. Waste streams will be treated and recycled on the site.

**What constitutes success?**

This project will be successful if the natural biodiversity and productivity of the forest can be maintained while sharing the same site with environmentally sensitive manufacturing businesses which create jobs and expand the local natural resource-based economy.

**EIP linkages.**

This project had focused on waste handling both for manufacturing businesses within the park and for the surrounding region. A basic premise of the project is that wastes generated will not be transported to already overloaded local wastewater and solid waste facilities.

**Recruiting process.**

Firms will be targeted that make new uses of local natural resources with low impact manufacturing processes.

**Resources available.**

To date this project has been initiated through a local partnership between the City of Raymond, the Port of Willapa Harbor, Weyerhaeuser Company, Ecotrust, a non-profit corporation dedicated to developing a sustainable economic base in the coastal forest s of the Pacific Northwest, and Shoretrust Trading Group. Planning resources and technical assistance have been provided by the State of Washington.

**Strategy to continue progressing.**

This green industrial park had been successfully kept on track through the efforts of an active local task force and frequent newspaper coverage. The task force is working with state and federal staff in a process created by President Clinton's timber initiative which focuses resources on priority community economic development projects. The green industrial park is the top ranked project in Pacific County.

**What is missing?**

This project requires additional technical and financial assistance to plan and develop the onsite infrastructure needed to support the resources processing businesses that will be located in this green industrial park.

**Goals for the upcoming workshop.**

Our goal for the workshop is to bring new ideas, information and resources home to help in our effort to build a viable sustainable economy in our rural Wills' community.

**12. SKAGIT COUNTY ENVIRONMENTAL INDUSTRIAL PARK**

Skagit County, WA

Address: (No address, still in planning)

City: Mt. Vernon State: WA Zip: 98273

Managing Entity: TBA

Contact Person' s Name: Kevin Morse

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Fax: (360) 336-6116

E-mail: eip@edasc.org

Alternate Contact Person: Don Wick

Phone: (360) 336-6114

Fax: N/A

E-mail: N/A

**EIP's key features.**

The key features of our EIP that differentiates it from a typical industrial park are:

- a recovery center built with energy efficient recycled content materials
- a manufacturing center
- a community center

- a sales and marketing center
- an environmental business center
- a closed loop system with minimal effluent and emissions
- highly visible park

**What constitutes success?**

Success for our EIP project will be indicated by:

- Land acquisition and infrastructure development
- The creation of safe, healthy, family wage jobs
- Minimal environmental impact
- Community support
- The self-sustenance of the venture
- The provision of recyclables to vital outlets
- The provision of revenues to replace money originally extracted from the now non-operational resource recovery facility

**EIP linkages.**

Development Steps:

- Feasibility study completed Fall of 1995
  - Identified three potential sites
  - Potential tenants
  - Local expansion and out of state relocation
  - Outlined components of EIP (see Executive Summary)
  - Economic Feasibility
- Recruitment of anchor tenants (in process)
- Recruitment of capital and development partners (in process)
- Working with state legislators to create incentives for green industries

**Recruiting process.**

We have done a feasibility study identifying local businesses interested in expansion or relocation to an industrial park. Currently, we are working with existing companies to acquire capital for expansion and equipment purchases. Throughout the history of the organization we have worked closely with the Washington State Department of Community Trade and Economic Development. Attempting to recruit new companies and gather information, we have attended many trade shows and conferences.

**Resources available.**

- The Environmental Industries Park has pulled funding from a number of sources.
- The Skagit County Government and the Economic Development Administration funded a feasibility study. Currently, we are seeking to fund land acquisition and infrastructure development. We have also received funding from the Forest Service for community revitalization. This contract will fund anchor tenant recruitment efforts.

**Strategy to continue progressing.**

In order for the Environmental Industries Park to progress, development partners will need to make a serious commitment of their capital and time. Until this is accomplished, progress will be slow.

**What is missing?**

Expertise in industrial development would help implement our EIP plans. Financing is crucial for our EIP's survival. An executive loan program would be welcomed. An industrial specialist from the public or private sector lent to our program for two years would make a world of difference.

**Goals for the upcoming workshop.**

I hope to learn from the struggles of other EIP developers and get more contacts within the EIP community. While there, I hope to make contacts for receiving funding and development assistance. I want to provide insight and lessons learned to policy makers so they can generate federal assistance.

**13. SHADY SIDE ECO-BUSINESS PARK**

Shady Side, MD

Address: 4800 Atwell Road, Shady Side, MD 20764-9546

Managing Entity: Business Ecology Network (BEN)

Contact Person' s Name: Joe Abe, President

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E-mail: abe@naturaledge.org

Alternate Contact Person: Gregg Freeman, Development Director

Phone: (410) 266-3216

Fax: (410) 266-8950

E-mail: Eloggie@aol.com

**EIP's key features.**

- Renovation of an existing facility in an underemployed and under served community.
- Integration of successful community-based tools and approaches from U.S. and abroad such as visioning, strategic planning, mapping of important resources and sites, and sustainable indicators.
- Refinement and demonstration of Business Ecology Round tables, an innovative approach for integrating profitability, stakeholder participation, and environmental performance
- Park ecosystem may include the following business: micro brewery, fish and shellfish aquaculture, a marine exploration and technology firm, an oil recycling business, an ecologically-designed water reclamation system, solar and renewable energy, and a compost business.
- Integration of the Internet, video and audio tapes, local printed media, and town meetings to reach stakeholders and communicate projects' progress.
- Demonstrating linkages among ecosystem health, the food system, community health, and economic opportunity.

**What constitutes success?**

- Economic, social and environmental goals are mutually achieved, creating powerful synergies that ripple within and outside the community.
- The community, businesses and the environment are so intertwined and mutually supportive that it's difficult to see where the boundaries between these systems begin and end.

**EIP linkages.**

1. Define the context, stakeholders and vision.
2. Develop and implement a communications strategy.
3. Develop a strategic plan for an eco-business park/community development center.
4. Implement the strategic plan.
5. Maintain the integrity and viability of the eco-business park/community development center.

**Recruiting process.**

This is proprietary information.

**Resources available.**

This is proprietary information.

**Strategy to continue progressing.**

This is proprietary information.

**What is missing?**

BEN has developed its Round tables process to support eco-business park development.

**Goals for the upcoming workshop.**

- Create strategic alliances and new opportunities.

**14. STONYFIELD LONDONDERRY ECO-INDUSTRIAL PARK**

Londonderry, NH

Address: 50 Nashua Road, Suite 100, Londonderry, NH 03053

Managing Entity: Town of Londonderry

Contact Person' s Name: Peter C. Lowitt

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E-mail: N/A

Alternate Contact Person: Nancy Hirshberg

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Fax: (603) 437-7594

E-mail: N/A

**EIP's key features.**

- Use of covenants to assure Industrial Ecology is model for the development.
- Adherence to Vision Statement.
- Eco-Auditing system to evaluate performance.

**What constitutes success?**

- Park tenants
- Jobs (500-2000)
- Increase community's tax base
- Positive Economic Impact as measured by independent study.

**EIP linkages.**

- Use of Covenants and Eco-Performance Standards
- Design guidelines being developed
- Active citizen participation processes
- Use of Advisory Board

**Recruiting process.**

- We have a committee developing a target industry strategy. This includes working with Businesses for Social Responsibility (BSR), local businesses and Realtors and an active multimedia promotion campaign.
- Existing Anchor tenants who will promote the park to like-minded corporations.

**Resources available.**

Town of Londonderry owns the land. Stonyfield Farms Inc. and Londonderry provide staff and seed money. Advisory Board includes EPA Region I, NH Charitable Foundation, MIT; NH Public Health; the Business Environment Network; UNH College of Life Science a and Agriculture's Sustainable Living Core Group; the Nature Conservancy, Businesses Social Responsibility and Area Citizens.

**Strategy to continue progressing.**

- Complete covenants and organizational structure
- Public Hearing for Town Council to ratify above
- Begin marketing

**What is missing?**

Model covenants, screening procedures for tenants, targeting, environmental performance standards all would be useful. Ownership models, lease, incubators, would all be useful.

**Goals for the upcoming workshop.**

Input from colleagues and other models.

**15. TRENTON ECO-INDUSTRIAL COMPLEX**

Trenton, NJ
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**EIP's key features.**

- Trenton's EIP will not necessarily be a physical place, but may be a network of businesses; firms won't need to be located next door to each other to participate; there will be a management structure to assist businesses with these linkages, matchmaking, and other technical assistance.
- Another key feature is the diversity of our Eco-Industrial Round table and the process it has undertaken to develop an EIP. The Round table is a multi-stakeholder steering committee comprised of representatives from government, business, non-profit and educational institutions.

**What constitutes success?**

- Success will be creating new jobs for our residents, increasing tax ratabilities, utilizing our Brownfields sites, creating value-added products that generate additional money in our local economy.
- Success will be more easily measured in terms of economic development, but at the same time we will improve the environment through less waste, less pollution and cleaner industries being recruited. We also hope to position Trenton as a "green" city.
- Success may initially be determined by expressions of interest from developers and attention by the media for this unique form of industrial development.

**EIP linkages.**

- Bruce Herrick, Ph.D., a Round table member, prepared a working paper that outlines the Round table's progress to date and its plan of action. The report also lists the potential linkages that the Round table had brain stormed.
- We hired Cornell University Work and Environment Initiative to conduct feasibility study and baseline assessment. We will survey the businesses that already exist in the region and their processes, inputs and outputs. We will then determine what other businesses can build off of those.

**Recruiting process.**

- We have produced one brochure on the project and recently sent out our first news release (our last Round table meeting was covered by a TV local Station and newspaper). We will continue a public relations campaign to attract business and developer's attention to the project.

**Resources available.**

- City of Trenton and NJ DEP - Contributing in-kind staff time to coordinate Round table activities. Also covers postage, photocopying and printing.
- DEP contributed $2,400 for preliminary Report.
- New Jersey Urban Enterprise Zone Assistance Fund - $25,000 Grant
- United States Economic Development Administration - $25,000 Technical Assistance Grant.
- Application to United States Environmental Protection Agency - $100,000 Sustainable Development Challenge Grant.

**Strategy to continue progressing.**

- Round table has outlined a time line in its first work paper.
- Must complete baseline study.
- Must secure additional $50,000 to continue study.
- Must continue to increase the business and development community's interest as the planning proceeds.
- Must secure funding to set up management structure and hire manager(s).
- Must recruit businesses and work with existing business to development networks.

**What is missing?**

- Interim and periodic successes to keep the Round table going.
- An input/output analysis of existing industrial processes and potential new recruits.
- Determine the best "mix" for Trenton that will build off of our competitive advantages.
- Evaluation method to determine success and/or failure.

**Goals for the upcoming workshop.**

- Create network of EIPs for information exchange and to share leads on potential business opportunities.
- Learn what obstacles others are facing and how they are dealing with them.
- Find out what resources there are to help (grants, technical assistance).
- Learn how to identify potential businesses and recruit them.
- Learn about management structures and how to pay for EIP management.
- Learn What Project XL can do for us.